POWER

Vol. 43 NEW YORK, MAY 9, 1916 No. 19

A GOOD WAY TO MISS OPPORTUNITY

Measuring the Water Used in Power-Plant Tests

By Charles G. Richardson

SYNOPSIS—Several ways of measuring water used in power-plant testing are described. Present methods are criticized and suggestions are made for those more practicable.

One of the most important factors in various kinds of tests conducted in power plants is the accurate determination of the water consumption. In certain calibrations the water used is the only result sought. Among power-plant tests where water must be measured accurately may be mentioned the following: Discharge of pumps, either in determining the pump efficiency or the supply to certain units; steam consumption of engines and turbines as obtained by condensing the steam; water evaporated in boiler tests; efficiency of boiler appliances intended to increase economy, and the calibration of water and steam meters.

Referring to the last item, water and steam meters have been liberally installed in power plants during the last ten years, and they have been most important in increasing boiler-plant efficiency—previously sadly neglected. It may be set down as good practice to establish their accuracy by occasional calibration. A reliable meter is the best means of measuring water from the viewpoint of expense and accurate results. One prominent electric company estimates that its boiler tests are now conducted by meter with greater accuracy and at about one-tenth the cost of the older methods. For the occasional calibration tests mentioned and for the measurement of water where meters are not available or suitable, the following suggestions should be found useful:

In power-plant tests the handiest unit to use is pounds. Therefore, to measure immediately suggests weighing the water, and weighed it has been for years. Ask an engineer today what method he will adopt to determine the water item of a proposed test and he will generally outline some arrangement involving a receiving receptacle mounted on a pair of scales. It is the purpose of this article to criticize present methods and suggest those more practicable.

Perhaps the crudest contrivance of all is the one outlined by Fig. 1. An ordinary barrel is mounted on scales and is repeatedly filled, weighed and emptied. Necessarily the test must be constantly interrupted to empty the barrel. An actual calibration so conducted on a meter recently came to the writer's notice where each individual run occupied only two or three minutes. Obviously there was a great possibility of error in taking the time period of each test, in making certain that all of the water that passed through the meter entered the barrel during each period and in giving the meter sufficent time to overcome its own inertia and "get up speed." That such a possibility of error became a fact was proved by the highly inconsistent results obtained.

Fig. 2 illustrates a common arrangement for weighing the water in a boiler test. Two barrels are used, each mounted on a scale. The feed water comes through the line *A*, and two weighers so manipulate the inlet valves *B* and *C* and the waste valves *D* and *E* that barrel No. 1 is being filled while No. 2 is being emptied. After each barrel is filled, it is weighed, the total pounds and the elapsed time being noted. Those who have conducted such tests will be free to admit the probability of errors in weighing and the confusion that follows a unusual demand for feed water. In fact, there is often a great deal of guesswork in such a method, especially if those operating the valves and scales have not had unusual experience. The method, however, has the advantage of permitting continuous operation.

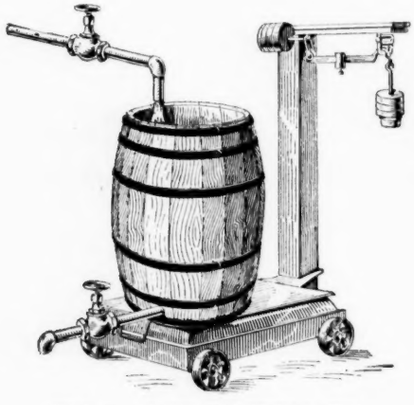


FIG. 1. CRUDE METHOD OF METERING WATER

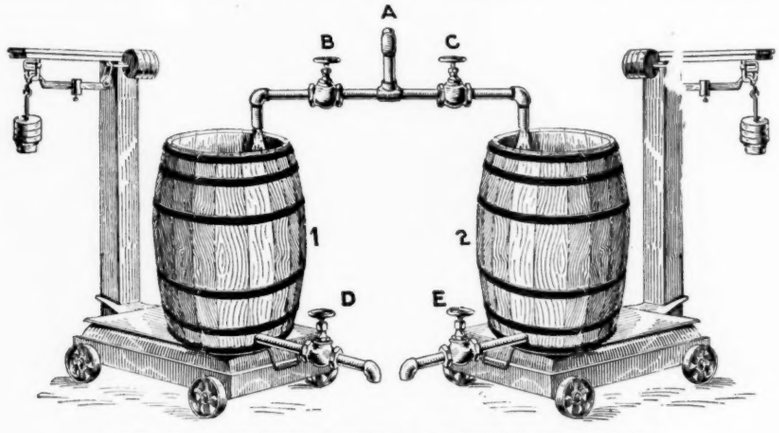


FIG. 2. A COMMON METHOD OF WEIGHING BOILER-FEED WATER

At the hydraulic laboratory of the Worcester Polytechnic Institute there is a wooden tank mounted on a large platform scale. The tank is approximately 10x12x6 ft. and holds 45,000 lb. of water. Therefore a half-hour continuous test can be made on a unit normally accommodating 3,000 boiler horsepower and proportionately longer runs for smaller units, such as pumps or meters. Provided the weighing is carefully done, this is an accurate arrangement. Few plants, however, would approve the cost of such an outfit and the larger the plant the more prohibitive becomes the cost.

Should there be on hand a large tank of any sort, but not water-tight, the method used at the Brown University laboratory might be warranted. Referring to Fig. 3, *A* represents the tank, which can be taken down and stored

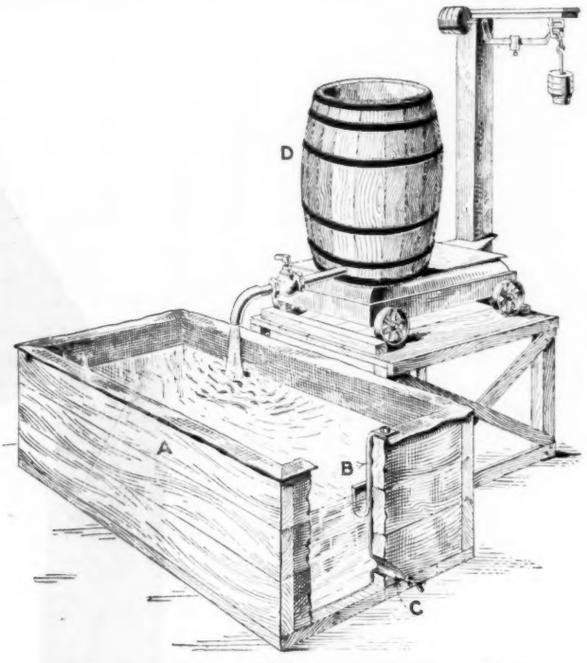


FIG. 3. CANVAS-LINED MEASURING TANK

when not in use. It is lined throughout with a removable waterproof canvas which is simply shaped to the interior without fastening. At *C* the canvas is brought through a hole in the tank and tied or clamped. The tank can be emptied through this opening. At *B*, and at lower points if desired, is fixed a hook gage. Water is then weighed into the tank from the barrel *D* until it is level with the point of the hook gage, and then the tank is emptied. If

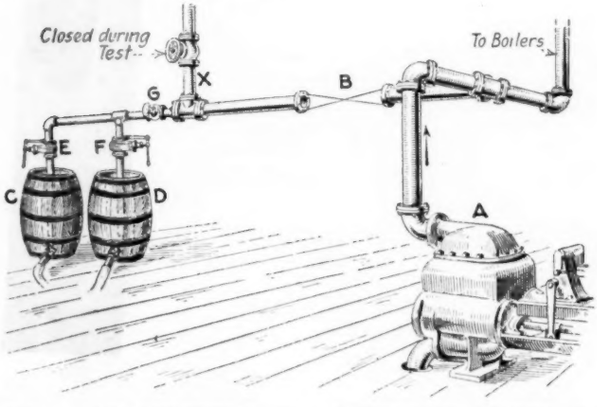


FIG. 4. ARRANGEMENT FOR MEASURING WATER BY VOLUMES OF PREVIOUSLY CALIBRATED WEIGHTS

the tank, therefore, is filled again to the same level a way is provided for accurately calibrating any unit discharging into it by taking the time period for such filling. Any leakage must of course be carefully caught and weighed. The hook gage must be located where the surface is not disturbed by the incoming water.

Fig. 4 illustrates how the idea of doing all the weighing before starting a test was actually applied. At *A* is a duplex steam pump and at *B* the unit to be calibrated. *C* and *D* are two ordinary barrels that can be filled and emptied by the valves indicated. Preceding the test the pounds of water each barrel would hold when filled was determined by actual weighing. *E* and *F* represent quick-opening valves, a necessary feature of the equipment. The piping was so arranged that there was no interruption to the feed to the boilers. The supply pipes to the barrels were carried to a point near the bottom to prevent

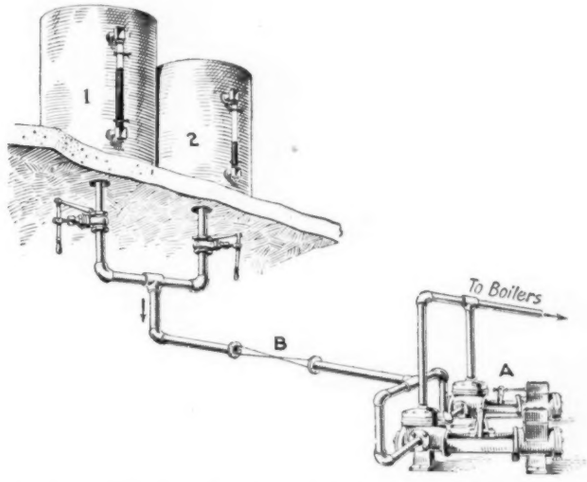


FIG. 5. ANOTHER METHOD OF WEIGHING THE FEED

disturbance of the water surface. It was not difficult to manipulate the valves so that each barrel could be filled to the predetermined point quite accurately, and the operator simply counted the number of times each barrel was filled. The pipe *X* is an auxiliary feed line to the boilers and was kept closed permanently during the test. The boilers were supplied through a vertical line above the pump and therefore all the water that passed through

FIG. 6. TANK FITTED WITH GAGE-GLASS

the unit *B* under test was passed into the barrels *C* and *D* through the valve *G*, which can be regulated to test unit *B* under different rates. Thus the test was continued for five hours without an interruption and with satisfactory results.

In Fig. 5 is an outline of the arrangement of a similar test conducted at the plant of the Brown & Sharpe Manu-

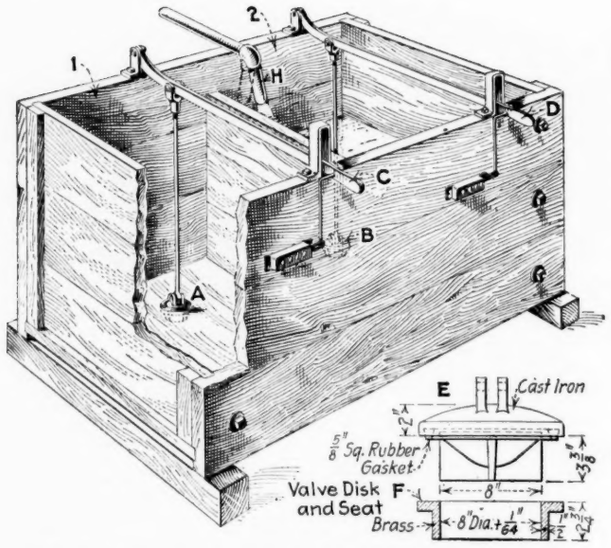


FIG. 7. CONVENIENT INEXPENSIVE TESTING TANK

facturing Co. In this case, however, the meter *B* under test was on the suction side of the boiler feed pumps *A* and the water was taken from open heaters. Each heater was fitted with a gage-glass, and previous to the test it was ascertained by "weighing in" how much water each would hold between certain marks (as shown by cords) on the glass. Each tank was then alternately filled up to the higher mark and emptied to the lower mark by manipulating the quick-opening valves. At the end of a ten-hour continuous test the total pounds pumped = (number of times No. 1 heater was drawn down × the corresponding weight) + (number of times No. 2 heater was drawn down × the corresponding weight).

A gage-glass is a valuable attachment to a hogshead or tank in running such tests. Not only can it be used for duplicate tanks, as outlined in the foregoing, but also with a single large tank. In this case it should be provided with a scale graduated in even pounds. Fig. 6 illustrates a large tank so fitted. If one long gage-glass cannot be

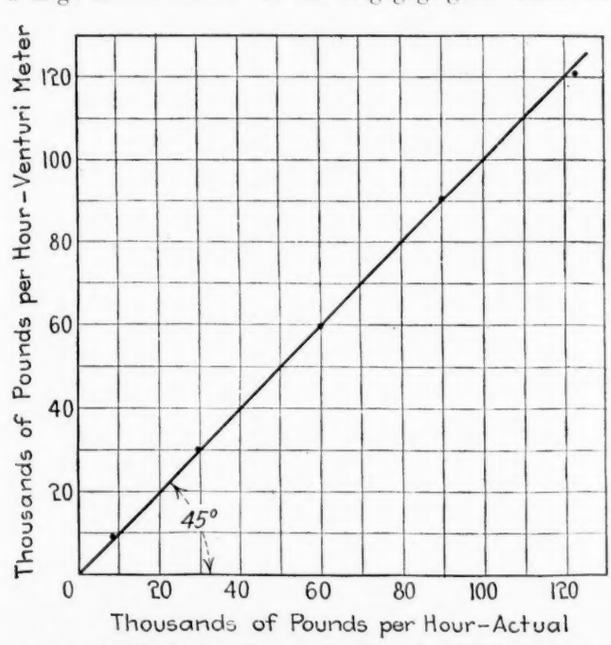


FIG. 8. CHART SHOWING HOW METER RESULTS COULD HAVE BEEN TABULATED

secured, two can be used, overlapping each other. The scale of course must be fixed in place and must be accurately calibrated by weighing in the water. The operator with a stop-watch can then note the time for filling and emptying the tank between each division, thus determining by similar readings of the unit under test whether the latter responds perfectly to changes in rate of flow. This is a much more satisfactory arrangement from every point of view than any float-and-pointer apparatus.

An ingenious and comparatively inexpensive testing tank for general work has been developed by Joseph R. Gill, master electrician of power, United States Navy, Boston, Mass. It combines the essential features of simplicity of operation, absence of any actual weighing and provision for conducting a test without interruption as long as desired. It is well worth a detailed description. Fig. 7 illustrates the construction. The outside dimensions are 8 ft. long, 3½ ft. wide and 4½ ft. deep. In the middle is a partition that divides the box into two nearly equal compartments, Nos. 1 and 2, except that the partition is only 3 ft. 7 in. high. At *A* and *B* are large waste

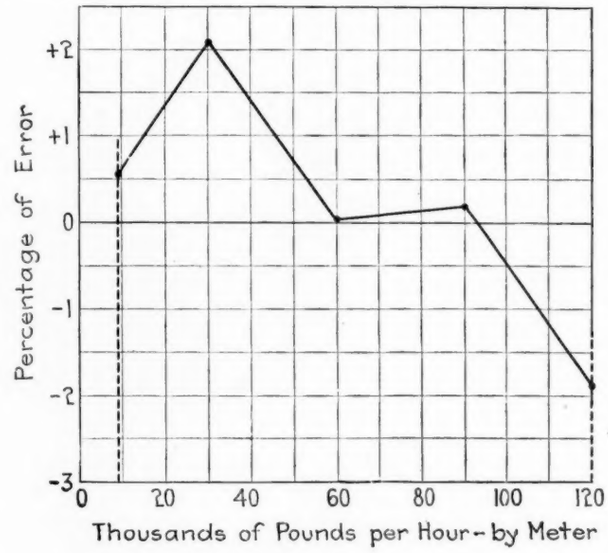


FIG. 9. CURVE OF METER ERROR

valves of special construction, which can be opened by the handles *C* and *D*. It is of course necessary that these valves do not leak, and several different designs were made before an entirely satisfactory one was evolved. The general design is shown in the detail illustration. The disk is weighted by a spherical section on the under side, and there are four guide wings that closely fit the seat. The dovetailed rubber gasket is an important feature. The valve is heavy enough to close tightly and yet be easily raised through the long leverage of the handle. Lately the tank has been lined throughout—bottom and sides—with sheet copper.

To calibrate the tank, water was weighed into compartment No. 1 until it wet about one-half of the upper surface of the partition. Then compartment No. 2 was similarly calibrated. Each side holds about 2,700 lb. of water. Once this calibration has been made and checked, there is no need of a repetition. During actual tests water is discharged through the pipe *H* alternately into the two compartments. No care is taken to fill the compartments exactly full—in fact, each is always filled until

the water flows freely over the partition into the other. Then the discharge pipe is switched from No. 1 to No. 2 compartment, and as soon as No. 1 has ceased overflowing into No. 2, it is emptied through the waste valve. It therefore becomes necessary simply to count the number of times each compartment is emptied for any length of test desired. Indeed, even the counting can be done automatically by a revolution counter or carfare register, as indicated—a useful but not essential refinement.

Engineers should more and more get accustomed to putting results of tests of almost any nature or even of everyday operation into the form of a curve. Thus a single diagram might contain numerous curves each having the same time period and representing pounds of water evaporated, load, pounds of coal burned, number of boilers in service, etc. This reveals an immediate comparison of important values. Frequently, however, curves are not put in the most useful form. For instance, a 4-in. Venturi meter was calibrated with the following results:

No. of Test	Pounds of Water per Hour—Venturi Meter	Pounds of Water per Hour—Actual Weight	Error of Meter, per Cent.
1	120,400	122.640	—1.87
2	90,000	89.820	+0.20
3	59,950	59,940	+0.02
4 and 5	30,000	29,370	+2.10
6 and 7	9,000	8,950	+0.55

Fig. 8 shows how the results might have been tabulated, since 100 per cent. accuracy would have placed the dots on a 45-deg. line, but such a chart is of little more value than the foregoing table. If we reduce results to a "curve of error," as given by Fig. 9, we immediately disclose to the eye the error characteristic of the meter for any rate of flow within the measuring range, which is shown by the dotted lines.

Troubles and Care of Ammonia Compressor Valves—I

By A. G. Solomon

SYNOPSIS—First of a few articles dealing with the construction, operation and care of the valves of ammonia compressors.

Whether a machine is single- or double-acting depends chiefly on the arrangement of the compressor valves. In single-acting machines discharge of the gas takes place at but one end; in the double-acting type both suction and discharge occur at both ends.

The valves of any type or make of machine are the most sensitive parts, and the greatest of all losses in refrigerating capacity is caused by valve trouble. Such trouble may be leaks, improper spring tension, sticking, breaking, derangement of parts, or restricted passages.

For an ammonia compressor to do its full duty and so handle the proper weight of gas the valves must be gas tight, of sufficient area, easy and quick in operation, and the springs must offer the least resistance possible. Scale and grit will cause the compressor valves to leak, stick and break. Small particles of scale from the inner surface of pipework, passing through the valves, will soon cut the seating surfaces, and then the gas will leak through. Pieces of scale or fine grit getting between the stem and the guide will make the valve stick, and this often causes the valve stem to break or bend.

When a new plant is built or new pipework installed, every piece of pipe and every fitting should be cleaned of scale and dirt. Every length of pipe should be stood on end and hammered to remove the scale. Fittings should be given the same treatment. When new pipework has been tested with air pressure, it should be blown out two or three times to remove loose scale. During the yearly overhauling the same precaution must be observed.

A suitable scale trap, with a fine-mesh screen must be installed in the suction line close to the compressor. This trap must be examined and cleaned at regular intervals. If this is not attended to, the passage of ammonia may be restricted or the scale may be drawn into the compressor. A few minutes' shutdown and a careful cleaning of the scale trap once a month may prevent a longer shutdown to replace a leaking or broken valve or to rebore a cut cylinder.

The first rule for the care of ammonia compressor valves is: Prevent scale or any foreign substance from passing through the system.

The packing of the ammonia rod on such machines as have a connection between the oil lantern and the suction line can also be the cause of valve trouble. "Chewed-up" packing will pass through this connecting line and get into the valves, where it will do the same damage as scale.

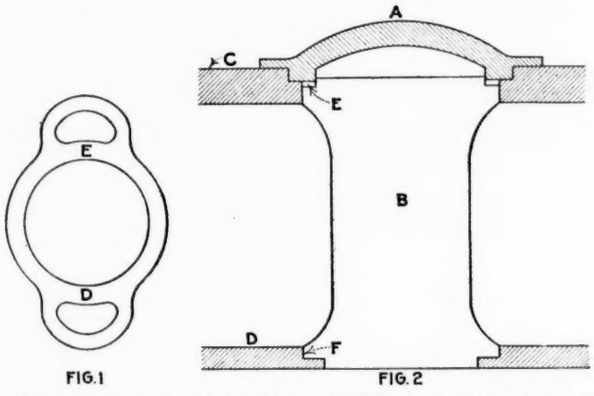
High discharge temperature together with inferior lubricating oil will cause trouble, as the oil will burn on the valves, causing slow action if not sticking.

There are several things which occur that often have the appearance of broken or leaking valves. The most common of these are: On machines of the Boyle type the gasket under the head and between the suction or discharge chamber and the cylinder can leak, and this has the same effect as a leaking valve. Fig. 1, *E* and *D*, shows places where this gasket may leak. If, as often happens, this gasket frequently blows out, the cause may be that the top of the cylinder or the head may not be faced true. If such is the case, the part that is not true must be faced. Pure gum sheet $\frac{1}{32}$ in. thick makes the best gasket for this place. When lead or other material has failed, thin pure rubber will usually give good service.

Leakage between the bottom of the valve cage and the head or cylinder casting produces the same effect as a leaking valve. As a rule a ground joint is used at this point, but if a gasket is required pure rubber or soft lead is best to use. A gasket cannot be used if the seating surface is not flat. On most horizontal compressors this joint is beveled and nothing but grinding with emery and oil will stop the leak.

A common cause for this kind of leak is found in such compressors where the cage is held in place by the valve bonnet. Perhaps, after grinding a cage to its seat or when putting in a new cage, the distance from the top

of the cage to the bottom is not great enough to allow the bonnet to press the cage down hard. Fig. 2 shows a short cage. To overcome this a washer or gasket of suitable thickness is cut and put in to make up for the cage shortage. Notice that this washer is narrow and does not extend out beyond the cage; *E* shows the washer, and *F* shows the joint under the cage. The washer at



FIGS. 1 AND 2. BOYLE LEAD GASKET AND VALVE GAGE

Fig. 2—A, valve bonnet cap; B, cage body; C, top head of compressor; D, bottom head of compressor; E and F, gasket joints

the top of the cage can be made of lead or rubber, but the best material is sheet iron. When the cage is of the proper length, it should be about $^1/_{64}$ in. above the surrounding part of the head where the bonnet rests. A short cage moving from its seat makes a noise like a broken valve.

A sticking valve is of course the same as a badly leaking one and will sound about the same as a broken spring. A valve thought to be either sticking or broken should be taken out at once, as an accident may be the result of neglect.

Ammonia blowing through the rod packing, oil lantern and gas-relief line has the same effect as a leaking valve, as the gas passes directly from the cylinder back into the suction. Leaking pump-out connections or the valves on equalizing lines are as bad as leaking compressor valves or leaking piston.

Besides the noises accompanying short cages and sticking and broken valves, there are other similar sounds, namely: Piston loose on the rod or striking the head; too much play of the piston rings in the grooves; broken piston rings; oil lantern or packing gland working back and forth. This last often happens when the back pressure is lowered below the usual point, as in pumping down.

There is a difference of opinion as to whether small or large clearance space is harmful in an ammonia compressor. Some makers allow much clearance to insure greater safety, while others do everything to minimize it to keep down reëxpansion losses. To keep the clearance as small as possible, the valves and cages are made flush with the heads. When this is done, the projection of the cage or valve through the head must be avoided.

Extra valves, cages, springs and all other parts that make the complete valve should be kept in stock. It does not pay to have parts of valves made in a local machine shop. Send to the factory for them, and by so doing the material and workmanship will be correct. There should always be a completely tested and assembled suction and discharge valve kept ready for immediate use. Then in the event of valve trouble the compressor can be pumped out and the new valve put in with the least loss. The defective valve is then repaired and put in stock. The foregoing gives a general idea of the care of compressor valves. To make the subject clear, the different styles of compressors must be explained as to their construction and the operation of the valves.

The distinctive features of the "Arctic" compressor are here described.

This machine is known as single-double acting and embodies the features of both the horizontal double-acting and the vertical single-acting. Each end of the cylinder is practically the same as a single-acting cylinder.

There are two suction valves in the piston and one discharge valve at each end of the cylinder. The piston is in two parts, each of which forms a complete piston for one end. The vapor from the evaporating coils enters the cylinder between the two pistons and passes through the suction valves. Fig. 3 shows the cylinder, piston and valves. Fig. 4 shows plainly the manner in which the suction valves are held in place.

The suction valve and locking, or retaining, ring *A* are made of chrome-vanadium steel which has been oil- and heat-treated; its tensile strength is about 200,000 lb. The valve is light and the bearing surface so large that the wear is seldom more than $^1/_{1000}$ in. after a year's usual operation. The valves and rings give little trouble, and any that may occur will usually be caused by some outside agency, such as scale from the inside of pipes. There are no springs, and the lift of the valve varies from $^1/_8$ to $^3/_8$ in., depending on the size of the compressor.

The retaining ring on the small machines is screwed on the face of the piston and kept tight by a taper dowel. On the large machines the ring is fastened in place by round-headed slotted capscrews sunk in to come flush with the face of the ring to reduce the clearance. Each of these capscrews is prevented from coming loose by a small screwed dowel.

A capscrew coming loose will cause a pound, as the clearance between the piston and cylinder head is not more than $^1/_{16}$ in. normally and often only $^1/_{32}$ in.

In a new plant the suction valve may cause trouble by sticking, owing to scale or other foreign matter lodging between the retaining ring and the valve. It is a short and easy job to get to the valves for examination or repairs, as both the front and back cylinder heads can

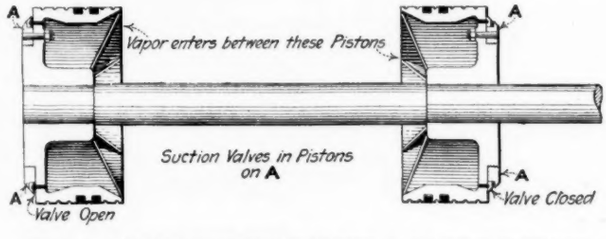


FIG. 3. LARGE SUCTION VALVES A IN THE PISTONS

be removed without disturbing pipework or other connections.

On machines up to 50 tons' capacity it takes only about half an hour to remove a head, examine the valve and be ready to run again. An extra retaining ring and valve should always be kept on hand for emergency use.

The discharge valves (see Fig. 4) are contained in cages and located at the lowest point at each end of the

cylinder. This location and the downward opening of the valves insure the least possible danger from accident caused by liquid in the cylinder.

In this machine the valve cage is held to its seat by a steel bar and setscrew arrangement *A*; a loose cage or leakage at the ground joint is almost impossible. The valves are of the poppet type, the guide being screwed into the cage and the valve working on the plunger-like end. Cushion is provided by means of small holes which

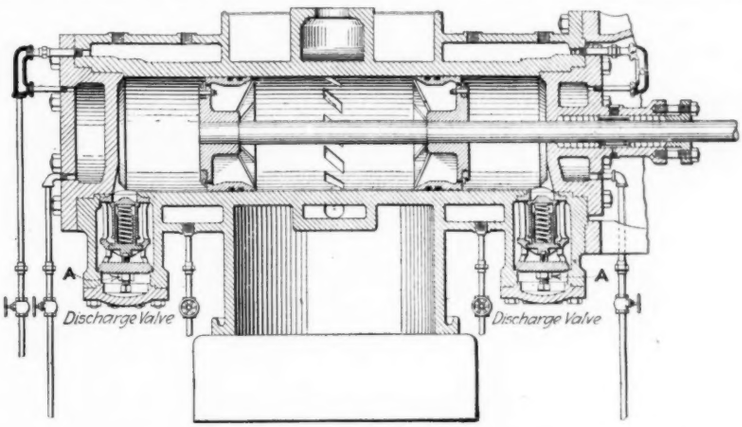


FIG. 4. SECTION OF CYLINDER, SUCTION VALVES IN THE PISTONS

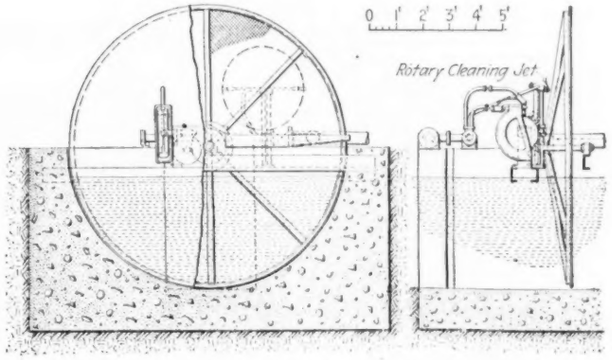
allow gas to pass in and out; the valve seats quickly and without shock. The fit of the valve on the guide must be such that binding will not occur. When wear takes place it is better to put in a new valve and guide rather than depend on bushings.

The next article will describe the features and care of valves of other compressors.

Rotating Intake Screens

A practical suggestion is found (in *Engineering* and *The Engineer*, England) in the general description of a new power plant at Manchester.

The condensing water is drawn from a canal through a 45-in. pipe line at the entrance of which there are duplicate rotary screens 10 ft. in diameter, formed of a circular



REVOLVING SCREEN IN FLUME

framework covered with wire netting, and turned at about one revolution per minute by a Pelton wheel through worm gearing. The screens are cleaned by jets which spray on their exposed portion on the side away from the incoming water. The performance of the screens is so satisfactory, that the more general adoption of the principle seems to be warranted.

JUST FOR FUN

The Mule's Prerogative

Speaking of Power Plants, the Court of Appeals of Kentucky, in a recent decision held that the right of a mule to kick is an inalienable prerogative, marked and commented upon from the earliest times. This court reversed a finding of a lower tribunal in the case of an employee of the Consolidation Coal Company, holding that when this plaintiff, a driver, stooped behind the mule's heels and then applied the lash "he not only invited disaster but provoked it." Later the opinion of the court said: "The mule requires no particular setting for the exercise of his high prerogative. He is liable to kick at any time and no one can plead ignorance of his tendency."—G. D. Crain, Jr., Louisville, Ky.

The Oil Was Heavy

The oil salesman called with his little bottles of marked oil samples, one of which read, gravity 28. The engineer asked what the 28 meant. Twenty-eight times heavier than water, replied the salesman. "Why," said the engineer, "I thought oil was lighter than water, seeing it floats."

Just then the factory chemist, just fresh from college, came along. He looked at the label and explained that gravity 28 meant that the oil was 28 times heavier than water. This was a jolt to the engineer, who again mentioned that oil floated on water. Later the chemist found that it meant 28 deg. Baumé—C. Wendall, Boston, Mass.

THAT INFERNAL QUESTION

How Reverse the Rolls?

An old rolling-mill plant when changed from engine drive to reversible-motor drive had a turbine-driven generator installed to furnish electric power. The old-time fellows of the mechanical department, familiar only with steam-engine drive, watched the erecting of the turbine with interest. After protracted examinations and finding no apparent way to run the turbine backward, they wanted to know how stock was to be got out of the rolls when stuck with that "new-fangled outfit."—S. O. Daeman, Philadelphia, Penn.

Carondelet Power Plant

By Thomas Wilson

SYNOPSIS—The new uptodate 1,250-kv.-a. station of the Laclede Gas Light Co. supplying electrical energy to operate a model domestic gas manufacturing and byproduct recovery plant. A feature of the station is the arrangement of the equipment. With no basement, the boilers are on the second floor. The turbines are mounted on steel superstructures at the same level, and the condensers and auxiliaries, exciters, etc., are on the first floor in light roomy quarters under the eyes of the turbine-room force.

The new $2,000,000 Carondelet plant of the Laclede Gas Light Co. in St. Louis is a model of its kind. It is the last word in a plant designed for the manufacture of domestic gas and the recovery of such valuable byproducts as coke, ammonia, tar and benzol. As may be known, benzol is the basis of aniline dye and many byproducts. The gas plant has 56 combination regenerative ovens, each having a capacity of 13¼ tons and designed for a coking time of 18 hr. It is on a site covering 180 acres at the junction of the Mississippi and Des Peres Rivers. The coal and coke-handling facilities are unusually complete, and the equipment in the byproduct plants is of the latest and most approved design.

High-pressure steam for use in the manufacturing processes and electricity for operating and lighting the gas plant are furnished by an uptodate power station containing 1,500 hp. in boiler capacity and two turbo-generators rated at 625 kv.-a. each. Following a plan that is beginning to find favor, the power-plant building is without a basement and wholly above ground. The boilers are set on what is really the second floor, and at the same level the turbo-generators are supported by a steel superstructure. The switchboard, mounted on a mezzanine floor at one end of the room, and the feed-water heater at the other end, are at the same general level, and convenient passageways connect them with the generating units. Below on the first floor are the condensers, auxiliaries and the pumps and exciters. Thus the entire equipment of the plant except the boilers is under the eyes of the operating force, and the men usually employed in an independent pumproom are eliminated. The construction is free and open, and the various machines are readily accessible. The same may be said of the piping, which at the back of the boilers drops down under the floor and is carried along under the turbines to the supply nozzles. Fig. 1 is an exterior view of the plant showing in particular the arrangement made for elevating coal from the track hopper to the bunkers. Fig. 2 shows the boilers and Figs. 3 and 4 the general layout of the plant.

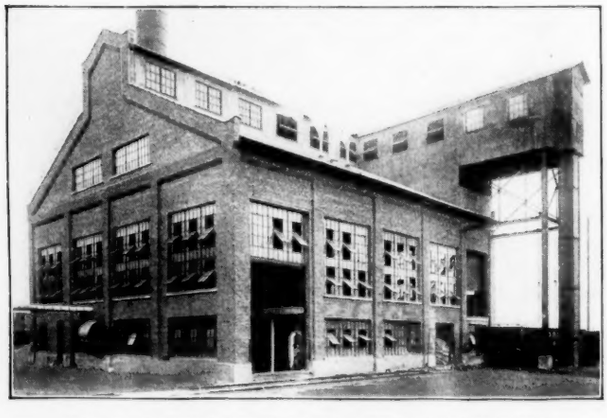


FIG. 1. THE POWER PLANT AT CARONDELET

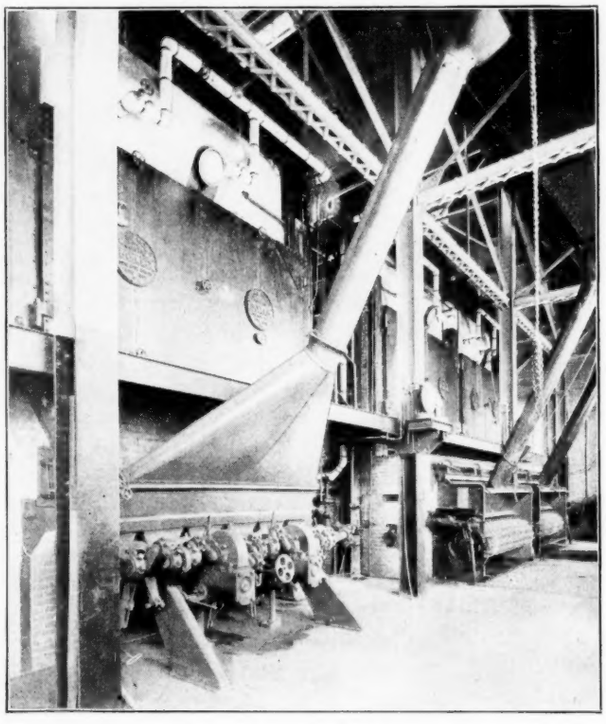


FIG. 2. VIEW IN FRONT OF THE BOILERS

The boiler room contains three 500-hp. water-tube boilers which are vertically baffled and of the four-pass type. In the last, or fourth, pass the gases flow downward to a smoke flue resting on the first floor and leading to the base of a 200-ft. self-supporting steel stack lined all the way up and 9 ft. 4 in. in diameter at the top. The boilers are equipped with superheaters, non-return valves, feed-water regulators and injectors. Each contains 5,160 sq.ft. of heating surface and 1,300 sq.ft of superheating surface, which is approximately 25 per cent. of the former. The boilers were built for 200 lb. pressure, but are operating at 175 lb. gage and 120 deg. of superheat. Two of the stokers are chain grates having 100 sq.ft. of surface, and the third is an underfeed six-retort stoker installed to burn coke breeze, which is difficult to burn with hand firing.

The smoke flue is of rectangular section with a 2-ft. crown. It is 8 ft. 9 in. wide and tapers from an average height of 3 ft. 3 in. at the far end to 9 ft. 9 in. between the third boiler and the stack. Its cross-sectional area at this point is then 85.3 sq.ft. This is about 25

per cent. greater than the free area at the top of the stack, which is 68.4 sq.ft. To the heating surface of the boiler the area of the chain grate bears a ratio of 1 to 51.6. From the preceding data it is evident that for each 1,000 sq.ft. of boiler-heating surface there are 19.3 sq.ft. of grate surface, 5.5 sq.ft. of smoke flue, and 4.4 sq.ft. of stack area. These proportions are consistent with the most recent requirements of standard practice.

At the entrance of the breeching to the stack there is a draft of 1¼ in. of water, and this reduces to 0.35 to 0.4 in. over the fire. A three-quarter housed paddle-wheel fan driven by a vertical engine supplies the draft for the underfeed stoker. There is space in the boiler room for another boiler to be served by an underfeed stoker, so that a fan large enough for the two was installed. The fan engine also drives the pistons of the underfeed stoker. Ordinarily two boilers are maintained on the line—one operating up to 50-per cent. overload and the other ready to be cut in should the pressure drop below 175 lb. A pressure regulator controls the speed of the fan engine. As usual the boilers have non-return valves, and the steam piping is equipped with valves of the venturi type. The load each boiler carries is indicated by a steam-flow meter.

Illinois screenings running about 10,000 B.t.u. per lb. is the fuel used at present. It is delivered in carload lots on a railway siding running close to the boiler room. The coal is dumped into a track hopper and through a shaker passes into a continuous bucket conveyor which, as shown in Fig. 1, extends beyond the track and delivers the coal into any one of four individual steel bunkers, each having a capacity of 50 tons. Through undercut gates controlled by chains from the boiler-room floor the coal passes from the bunkers into the chutes supplying the stoker hoppers. The conveyor and shaker are both motor-driven, and the capacity of the system is 40 tons per hour.

Ashes from the stokers are dropped into firebrick lined draft-tight hoppers immediately beneath the second floor. The contents of these hoppers are removed in an in-

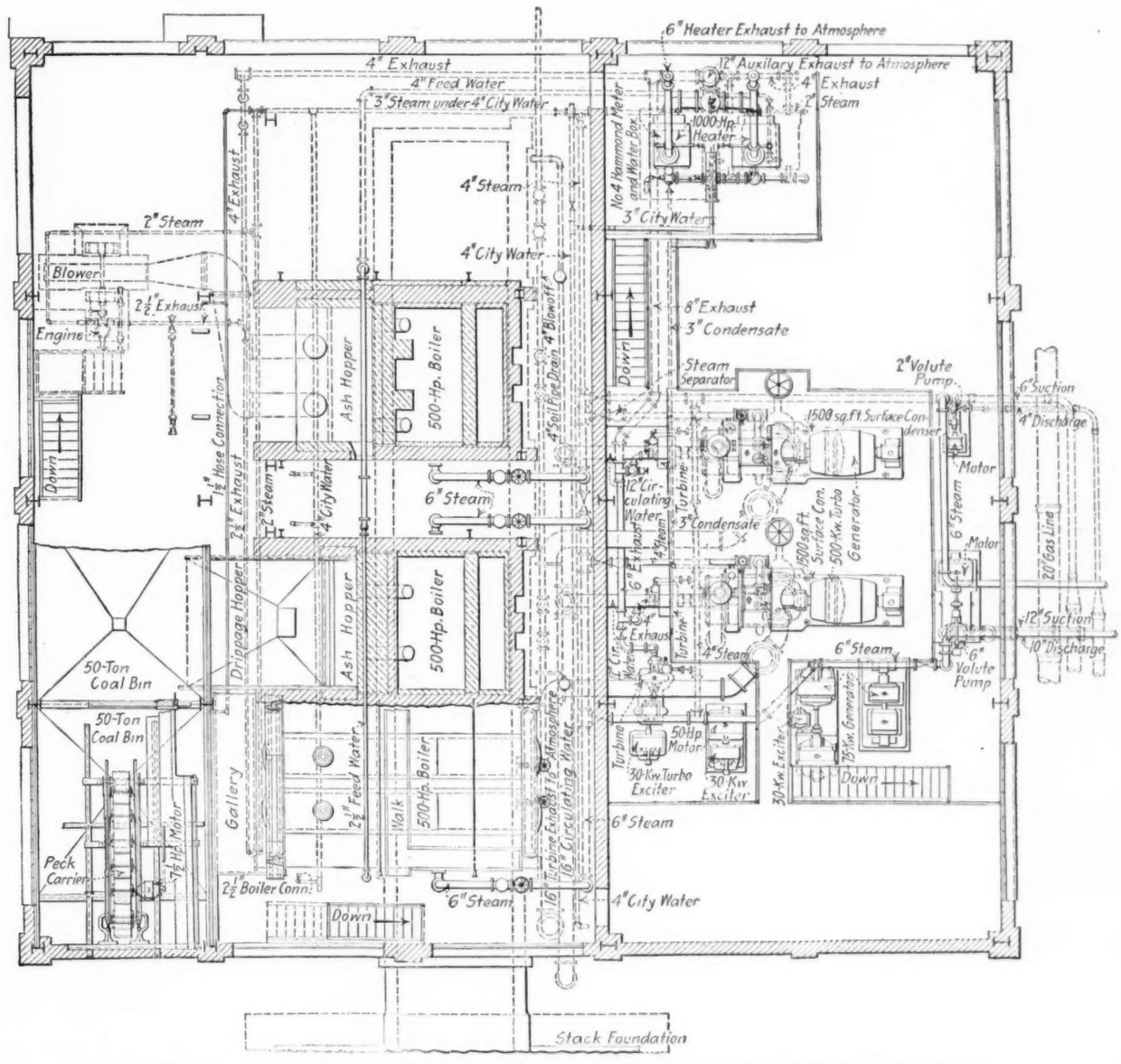


FIG. 3. PLAN OF THE BOILER AND TURBINE ROOMS OF THE CARONDELET PLANT

dustrial car on the first floor and dumped in the yards wherever filling is needed. Fine-coal hoppers under the chain grates also discharge into the industrial car, but this coal is dumped into the track hopper and eventually finds its way back to the boilers. Chutes connecting the ash hoppers with the secondary combustion chambers back of the bridge-walls provide for the removal of soot.

For the most part the feed water consists of condensate and turbine gland water. The makeup is drawn from the storage or spray pond as needed. This water is collected in two open feed-water heaters connected in parallel and each rated at 1,000 hp. There is sufficient exhaust steam from the auxiliaries to maintain the boiler feed at 206 deg. From the heater the water flows by gravity through a dumping meter and receiver to one of two three-stage centrifugal pumps driven by steam turbines at 2,000 r.p.m. These pumps are in duplicate, as either is capable of supplying the three boilers. On the suction side the pumps are so connected that they may also draw their supply from the spray pond which cools the condenser circulating water.

In the generating room the main units are the two 625-kv.-a. turbo-generators shown in Fig. 5. The turbines are of the horizontal reaction condensing type, operating at 3,600 r.p.m. on steam at 175 lb. pressure and 100 deg. of superheat. The generators are four-wire three-phase machines delivering 60-cycle current at 4,150 volts. Ordinarily one machine is sufficient to carry the load. The voltage is stepped down to 440 for power and 110 volts for lighting.

The surface condensers serving these machines are of the unit type. Centrifugal air, circulating and condensate pumps are all hung to the condenser and, as they are all mounted on one shaft, are driven by a single 50-hp. turbine. The condensers are immediately beneath the turbines, and the whole makes a very compact unit readily accessible and well-lighted, owing to the open construction of the second floor. The auxiliaries are designed to deliver full rating on 130 lb. of steam, so that a considerable drop from the operating pressure of 175 lb. would be necessary before they would fail to perform their respective functions.

Each condenser contains 1,500 sq.ft. of surface, which is an allowance of 3 sq.ft. per kw. of generator rating at 80 per cent. power factor. With 1,700 gal. per min. of 70-deg. cooling water and 11,000 lb. of steam, they are guaranteed to maintain a vacuum of 28.6 in. referred to a 30-in. barometer. Under the operating conditions existing in the plant, a vacuum within one inch of absolute has been maintained. Operating under 175 lb. steam pressure, 100 deg. of superheat and a vacuum of 28 in., the guaranteed water rate of the turbines when delivering 500 kw. at 80-per cent. power factor is 16.6 lb. per kw.-hr. With the higher vacuums maintained in the plant, the water rate at full load should be slightly less. At 50-per cent. overload under the conditions cited, the guaranteed water rate is 17.2 lb. per kw.-hr. This would require each square foot of the condenser to care for close to 8 lb. of steam per hour.

Cooling water for the condensers is obtained from the 1,000,000-gal. concrete spray pond shown in Fig. 6. This is 100 ft. wide by 200 ft. long and 6 ft. deep. A wall

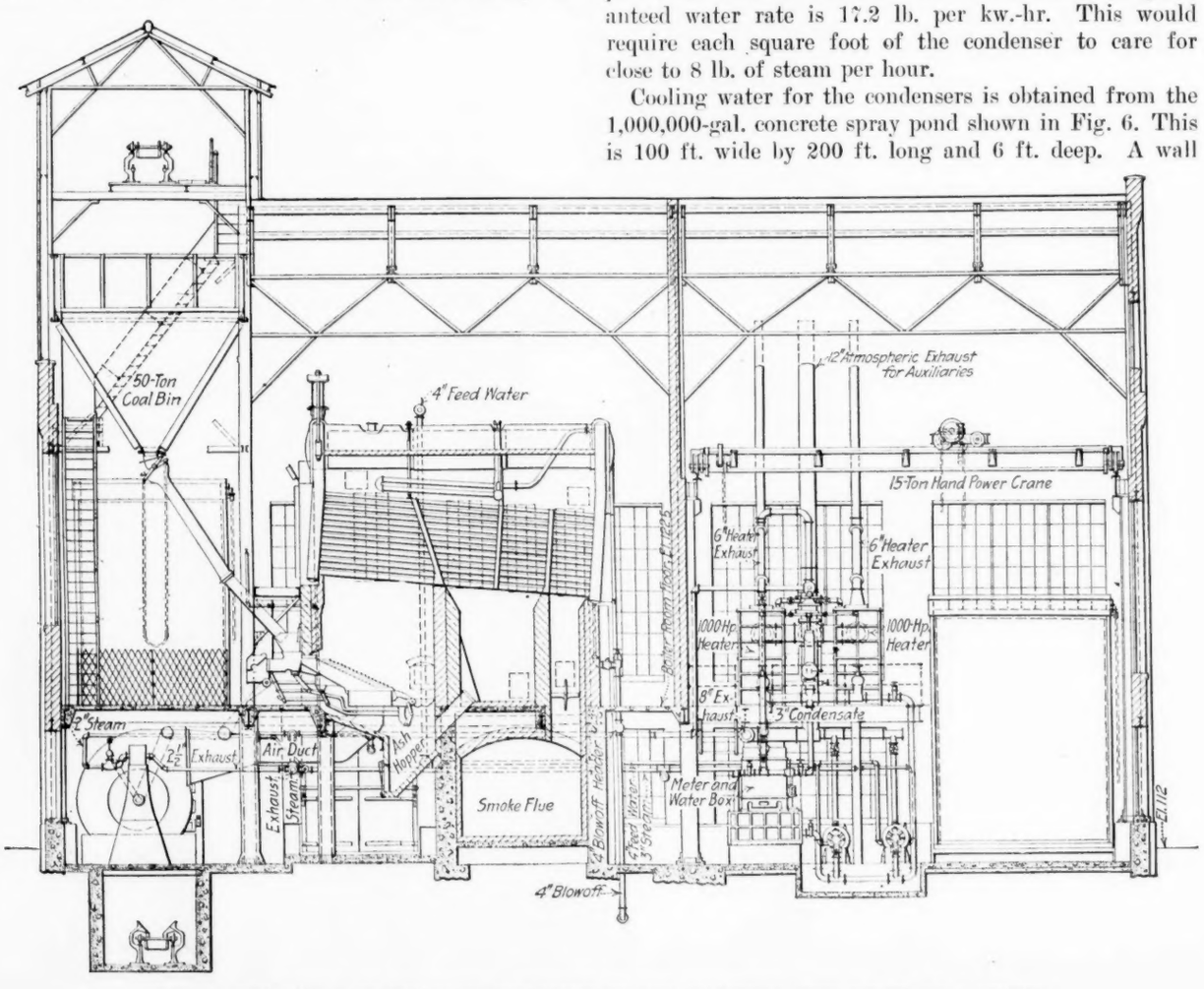


FIG. 4. SECTIONAL ELEVATION THROUGH PLANT, SHOWING THE GENERAL LAYOUT

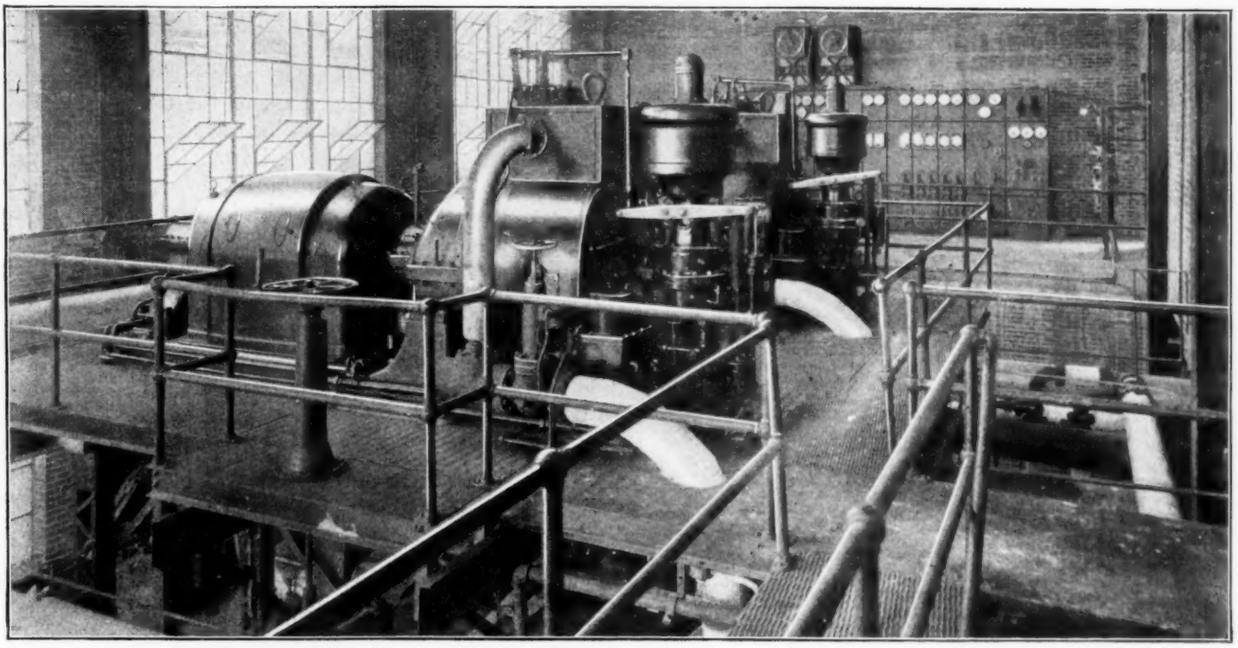


FIG. 5. MAIN GENERATING UNITS. THE SWITCHBOARD IS SHOWN IN THE BACKGROUND

divides it at the center into two ponds, so that the condenser supply may be drawn from one while the other is being cleaned. A 16-in. header at the side of the pond supplies four 8-in. branches. From each branch four 4-in. risers supply a cluster of five nozzles, so that in all there are 80 nozzles on which a head of 5 to 12 lb. is maintained by the condenser circulating pumps. The pond was designed to cool 3,000 gal. of water per minute. Through a 20-in. main the water is conducted to a cistern just outside the power plant from which the circulating pumps draw their supply. River water might have been used directly, but the elevation is 40 ft. and the horizontal run 800 ft., so that the pond was considered a profitable investment, offering large storage facilities. Besides the pond gives the river water, which carries considerable foreign matter in suspension, a chance to settle. At times of cleaning the pond must be refilled, and the water is raised by either one of two motor-driven

PRINCIPAL EQUIPMENT OF CARONDELET POWER PLANT OF THE LACLEDE GAS LIGHT CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Boilers	Water-tube	500-hp	Generate steam	175 lb. press., 120 deg. superheat	Edge Moor Iron Co.
3	Superheaters	Foster	1,300-sq.ft.	Superheating steam	120 deg.	Power Specialty Co.
2	Stokers	Chain-grate	100-sq.ft.	Serve boilers	Driven by fan engine	Illinois Stoker Co.
1	Stoker	Taylor underfeed	Six-retort	Serve boilers	Driven by fan engine	American Engineering Co.
1	Fan	Paddlewheel, housed		Forced draft to underfeed stoker	Driven by vertical engine	American Blower Co.
1	Engine	Simple vertical	6x7-in.	Drive forced-draft fan	Controlled by Mason governor	American Blower Co.
1	Conveyor	Peck bucket	40 tons per hr.	Coal from track hopper to bunkers	Driven by 7½-hp. Westinghouse ind. motor	Link-Belt Co.
1	Shaker		40 tons per hr.	Feed coal into conveyor	Driven by 5-hp. Westinghouse ind. motor	Link-Belt Co.
3	Injectors	Live-steam		Feed water to boilers		William Sellers & Co.
3	Meters	Steam-flow, indicating		Indicate output of boilers		General Electric Co.
2	Pumps	Three-stage centrifugal	2½-in.	Feed water to boilers	Driven by Westinghouse turbines, 2,000 r.p.m.	Jeanesville Iron Works Co.
2	Heaters	Serge-Cochrane, open	1,000-hp.	Heat feed water	Connected in parallel	Harrison Safety Boiler Works
1	Meter	Dumping		Measure feed water		Alberger Pump and Condenser Co.
2	Turbines	Reaction	625-kv.-a.	Main generating unit	175 lb. press., 100 deg. superheat, 3,600 r.p.m.	Westinghouse Machine Co.
2	Generators	Three-phase, 60-cycle	625-kv.-a.	Main generating unit	4,150 volts, 3,600 r.p.m.	Westinghouse Electric & Mfg. Co.
2	Condensers	Surface	1,500-sq.ft.	Serve main units	Av. vac. 1 in. from absolute	Westinghouse Machine Co.
2	Pumps	LeBlanc rotary	225-gal. per min.	Air from condensers	Same shaft as circ. and cond. pumps	Westinghouse Machine Co.
2	Pumps	Centrifugal	1,700-gal. per min.	Circulate condenser water	Same shaft as air and cond. pumps	Westinghouse Machine Co.
2	Pumps	Centrifugal	25,000-lb. per hr.	Condensate to heater	Same shaft as circ. and air pumps	Westinghouse Machine Co.
1	Pump	Centrifugal	1,500-gal. per min.	Emergency	Driven by 75-hp. Westinghouse ind. motor	Henry R. Worthington
1	Pump	Centrifugal	100-gal. per min.	Service	Driven by 7½-hp. Westinghouse ind. motor	Henry R. Worthington
1	Air compressor	Locomotive type	Steam, 8½x14½x12-in.; air 9x14½x12-in.	General use about plant	100 lb. air pressure	Westinghouse Air Brake Co.
1	Filter	Pressure	No. 2	Purify turbine oil		V. D. Anderson Co.
80	Spray nozzles		2-in.	Cool condenser water	5 to 12 lb. pressure	Spray Engineering Co.
1	Exciter	Electric drive	30-kw.	Excite main units	Driven by 45-hp. Westinghouse motor, 1,200 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Exciter	Steam drive	30-kw.	Excite main units	Driven by Westinghouse turbine, reduction gearing	Westinghouse Electric & Mfg. Co.
1	Motor-generator		75-kw.	Furnish direct current	Driven by 112-hp. ind. motor	Westinghouse Electric & Mfg. Co.
1	Motor-generator		60-kw.	Furnish direct current	Driven by 90-hp. syn. motor	General Electric Co.
2	Pumps	Centrifugal	2,000-gal. per min.	Water from river to spray pond	Driven by 150-hp. Westinghouse ind. motors	Henry R. Worthington
2	Engines	Poppet-valve	15x18-in.	Drive positive-pressure blowers	130-lb. steam, 200 r.p.m.	Nordberg Mfg. Co.
2	Blowers	Positive-pressure	28-cu.ft. per rev.	Pump gas from plant	5 to 6 lb. pressure	Connersville Blower Co.
3	Engines	Simple	16x16-in.	Drive pos. press. blowers	140 lb. steam 15 lb. b.p., 240 r.p.m.	Erie City Iron Works
3	Blowers	Positive-pressure	38-cu.ft. per rev.	Pump gas from ovens	2 lb. pressure	Connersville Blower Co.
1	Crane	Hand-power	15-ton	Serve engine room		Whiting Foundry Equipment Co.

Switchboard, instruments and transformers, Westinghouse; Edwards nonreturn valves and Chapman venturi type valves on steam piping.

pumps installed in a pit at the bank of the river. The center line of the pumps is approximately 9 ft. above the zero stage of the river, which is 2½ ft. above the low-stage level, so that the suction lift should never be more than 11½ ft.

For exciting the two main generators there are two 30-kw. exciters, one driven by an induction motor and

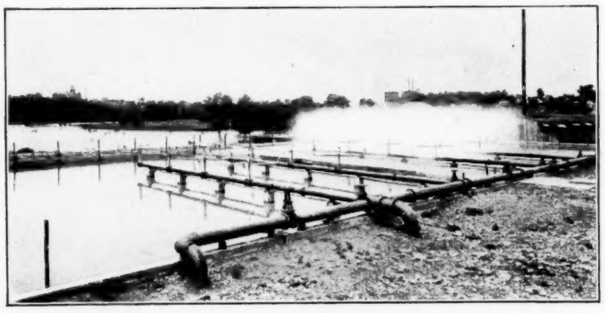


FIG. 6. THE 1,000,000-GAL. SPRAY POND

the other by a steam-turbine through a 4½-to-1 reduction gear. As direct current is required at 250 volts for motors on the oven machinery, box-car loaders and some Cooper-Hewitt outside arc lamps, two motor-generator sets have been provided, one having a capacity of 75 kw. and the other, 60 kw.

The high-tension current from the alternators is delivered through remote-control oil switches to the busbars in a cell room on the first-floor level. From the busbars the current is distributed through lead-covered cables laid in fiber ducts surrounded by concrete. The switchboard, which has eleven panels of black slate, carries the usual instruments.

Among other equipment in the turbine room is a motor-driven emergency pump which fulfills the fire underwriters' specifications. In series with another pump it will operate against a head of 213 ft. Then there is a small service pump, which has various uses, and a steam-driven air compressor of the locomotive type, which furnishes compressed air for the motor of the boiler-tube

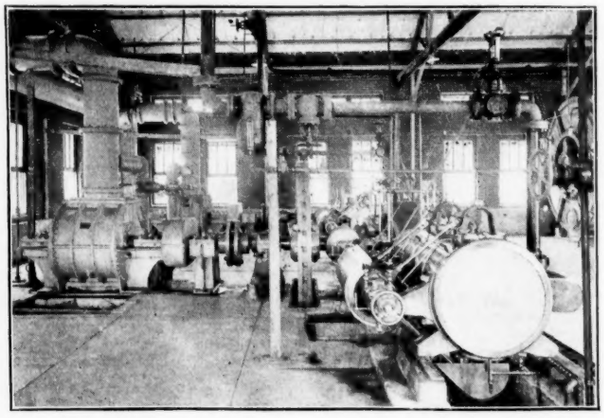


FIG. 7. A VIEW OF THE GAS-PUMPING PLANT

cleaner, for blowing dust from the generators, for elevating oil, etc.

A pressure filter with a capacity of 20 gal. per hr. has been provided to purify the turbine oil. In the base of each turbine there is an oil-storage reservoir of considerable capacity, from which the oil is pumped to the bearings and to which it is returned by gravity. When the oil begins to show signs of becoming dirty, the turbine reservoir is entirely emptied by allowing the oil to flow by gravity to the dirty-oil tank of the oil filter located on the first floor. The drain-pipe cock is then closed, and air pressure forces the dirty oil from the tank through the filter into a second tank provided to store the clean oil. From here the oil is again forced by air pressure to the storage at the turbines.

Although much of the plant is served by the central power station, there were places where independent engine units were installed, these being supplied with steam from the main boiler room. One of these places was the gas-pumping station by which the gas is pumped away from the plant against a pressure of 5 to 6 lb. Exhaust steam was needed for heating the station and the cups and water tank of the holder. The amount of exhaust steam required for these purposes was limited, so that highly economical engines were chosen to drive the positive-pressure blowers installed to pump the gas. The pumping units are shown in Fig. 7. The engines are of

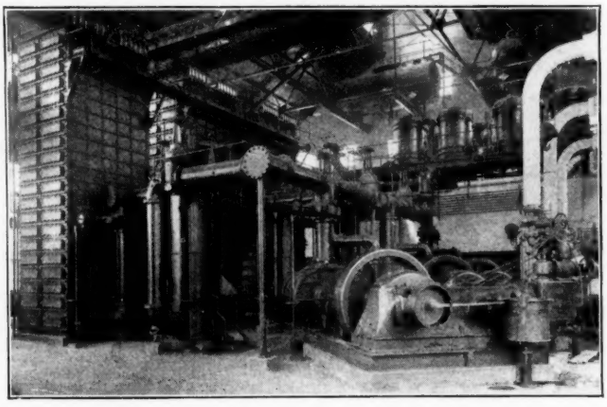


FIG. 8. GAS-PUMPING UNITS IN BYPRODUCTS PLANT

the poppet-valve type, 15x18 in. In the acceptance tests, which were described in the Sept. 7, 1915, issue of *Power*, the steam consumption per indicated horsepower-hour at the most economical load was found to be 18.85 lb. Referred to the Rankine cycle this corresponds to an efficiency of 79.9 per cent., which is remarkably high when it is considered that the steam upon reaching the engines had a pressure of only 130 lb. and contained about 1 per cent. of moisture.

In the byproduct building, Fig. 8, three simple non-condensing engines are employed to drive positive-pressure blowers, which draw the gas from the ovens and force it through the condensing apparatus into the lean- and rich-gas holders. The engines operate against a back pressure of 15 lb., as the exhaust steam is utilized in the ammonia concentrators the year around. Consequently there is no particular desire for low steam consumption, as all of the exhaust steam is needed.

The plant was designed and installed by the engineers of the company. George B. Evans is chief engineer; Thomas H. Turner, construction engineer; Donald MacArthur, superintendent of manufacture; and J. T. Tierney, superintendent of the coke station and power plant.

High Fire-Test Oil is necessary to lubricate bearings operating at high temperature; other oil may actually increase the bearing temperature.

Filtration of Softened Water

By F. F. Vater

SYNOPSIS—The best way to remove suspended matter is to filter downward through sand. Never use a coagulant in boiler-feed water. Several cases are cited in which a sand filter would have effected a large saving over sedimentation or an inadequate filter.

For boiler-feed water a device that will arrest and separate matter mechanically suspended in water and that is visible to the unaided eye is a filter. This requirement is well within the limit of attainment, and any device that does less than this (accurately speaking) is only partly a filter or an inadequate filter.

The first cost of a most suitable filter must be justified in the savings in boiler operation resulting from the higher efficiency. Often it is not realized until too late what these savings are and what possibilities of waste have been overlooked.

There recently came under the writer's observation a case that illustrates this point. A central station purchased a water-softening system that had an inadequate filter, primarily because it cost less money. Troubles from sludge arose at once, as much visible suspended matter remained in the treated water. This sludge stopped the feed lines, got into the flow meters, made the feed water regulators inoperative and also caused foaming and priming. The manufacturer, being told of the trouble, recommended sulphate of iron as a coagulant to aid the work of the inadequate filter. He either did not know that sulphate of iron did not coagulate until it had released its sulphuric acid, becoming iron hydrate and leaving free sulphuric acid in the water, or was careless and failed to remind the company of the fact.

Use of Coagulant Proved Costly

This coagulant cost the company about $300 a year, which is 20 per cent. interest on the greater cost of a filter that would have made the use of a coagulant unnecessary. Saving the $300 a year spent for coagulant for five years would have seen the filter paid for, and the company would still have been earning that 20 per cent. dividend. It was evidently false economy to save the $1,500 on first cost. But the whole story has not been told.

Sulphuric acid remained in the boiler-feed water after being released from the sulphate of iron. It was there in small quantity, and some of it was no doubt taken up by the lime remaining in the treated water. Four years passed. In the interim, mention had been made of the serious depreciation in the boilers, but little attention had been paid to the warning of the inspector. The culmination came in four years and it hurt. Just 1,100 hp. of boilers were condemned. Over $16,000 had to be spent to replace those boilers into which water had been fed after treating it with sulphate of iron. In the four years the company had spent $1,200 for coagulant and a part of $16,000 more by failing to buy a good filter at first. Only part of $16,000 is given because the new boilers installed have a longer life ahead of them than the abandoned boilers had and are intrinsically worth more money. Place the percentage of loss from sulphuric acid at whatever may be thought fair, it can never be so small that the failure to purchase a good filter could be considered economical.

Sulphate of iron is not the only coagulant that would have given trouble. Sulphate of alumina would have given the same result. Any coagulant used commercially would have caused trouble. Therefore, do not use a coagulant. It will mean money ahead to put up with the trouble caused by the sludge.

This may be an extreme case. Certainly it was expensive and should suggest that if anything is worth doing at all, it is worth doing well. In other words, when purchasing a water softener, pay enough money to get a good filter as a component part, and not an inadequate filter.

Filter Downward Through Sand

All efficient filtering plants in this country pass the water downward through sand, the filtering medium being cleaned by reversing the flow of water through it. Upward filtration is working directly in opposition to natural laws. A filter bed must be fine and compact so it will retain the small particles. Upward filtering loosens up the sand and causes openings through which the suspended matter may pass.

Attempting to filter through cloth, excelsior or wood fiber is not practical. Great care may be taken to pack an excelsior filter bed evenly and of equal density, still in twenty-four hours there will be holes through it because it slacks. Any attempt to obtain satisfactory results from this medium will require almost constant renewal of excelsior and the spending of time that might be employed on some work giving better returns. When using sand as a filtering medium, there is practically no renewal expense. Plenty of filters in use for ten years still employ the original sand.

Another plant in which steam is generated to supply blowing engines, as built originally, was equipped with a water softener depending on sedimentation alone. Since rated capacity was required from the boilers, this softener has always given trouble.

Lime and soda ash were used, and the large tanks were treated intermittently. The precipitate did not settle out, but passed into the boilers. Sludge is a first-class substance to leave in the water if foaming and priming are desired. A softened water is naturally lighter and will foam more readily than an untreated water, because the treatment has reduced its density.

A Costly Substitute for Soda Ash

The priming became so severe that it was necessary either to abandon the use of the softener or to drop the soda ash and substitute barium hydrate, as the latter leaves no byproduct in the water. This chemical will do the work, but the cost was 7c. per 1,000 gal., the water being treated to 7½ grains of hardness, 3½ of which was temporary and 4 permanent. The permanent hardness being the sulphate of lime and magnesia, which is the cement which forms scale and makes it hard, and being in greater quantity than the temporary or carbonate hard-

ness, the scale is hard and there is plenty of it; so much in fact that in a plant containing fourteen 350-hp. water-tube boilers a crew was kept busy turbining tubes.

It costs money to turbine tubes, but neglecting that item, the loss of money resulting from the use of barium hydrate instead of soda ash, which could be used were filters installed, was considerable. As previously stated, the cost of using barium hydrate was 7c. per 1,000 gal., and 24,000 gal. being required each hour, the chemical cost of treatment per hour was $1.68, and for 24 hr., $40.32. Using soda ash, the chemical cost would have been 2½c. per 1,000 gal., or 60c. an hour, and $14.40 a day. The lack of filters therefore cost $25.92 per day and for the year, $9,460.80 The plant operates 24 hr. a day, 365 days a year.

A filter plant here would have cost about $3,000 and would therefore have paid for itself in about four months. Such things must occur and be talked about or there would be no progress. The tendency of the times, however, is encouraging. The wide-awake man is learning that the limit of capacity of a steam boiler is governed by the purity of the water used and by the amount of heat a tube will transmit to the water. There is no excuse today for investing in much more than a 500-hp. boiler to produce 1,000 hp. of steam. All other conditions being right, it cannot be done unless the water is good, and no water can be good which, after being softened, passes through anything but a good filter.

Another interesting experience is that of a large manufacturing company, operating several plants, that believed in a water softener and invested money in one. A type using an inadequate filter was purchased, and trouble from sludge soon developed. It interfered with the flow meters, feed-water regulators and the recording thermometers and gages. The trouble became so serious that on a boiler in one plant a combined skimming and filtering device with forced circulation was installed. In other words, the company was trying to remove the sludge after it had entered the boiler instead of taking it out before it got there.

One boiler only was equipped at a cost of $800. The plant had ten boilers, so that the cost for the skimming and filtering equipment for the plant would have been $8,000. This is more than the softener cost originally. How much better it would have been to have invested in filters when the softener was first installed. There is still little doubt that the company would repeat the mistake if it were to buy another softener. It is really surprising that so many of us not only do not learn by the mistakes of others, but do not learn even when we have footed the bill.

After the water is treated for boiler-feed use, there is more to the problem of filtration than appears on the surface. It is not a question alone of so many square feet of sand of a certain fineness and depth of bed, but of what the substance is that is to be removed and what are its characteristics. An analysis of a water does not tell the story. A certain plant uses a softened water that before treatment contains about 35 grains of incrusting matter per gallon. The precipitate is composed of lime and magnesia carbonate, nevertheless it is so fine it feels as though it contained oil. It is also as sticky as a combination of sediment and oil would be. It would stop up a filter bed of standard size for the quantity of water handled in three hours. A filter large enough to handle it would cost more in first investment, but it would cost so much less to operate that it would pay well on the investment.

There may be and no doubt are some plants where inadequate filters are installed and giving satisfactory service, as their purchasers see it. Possibly they do not know that trouble is not necessary, and possibly the water is of such a quality that filters would not be necessary, but this last seldom happens.

Engineers' Operating Data File

By Charles H. Bromley

SYNOPSIS—A 14x5x4-in. filing drawer serves as a receptacle for cards bearing important data about the plant, its machinery and supplies. Typical cards from the drawer are shown.

With little more time than it takes to swing around in your swivel chair, could you tell the names and sizes of the attachments on your boilers; or the sizes of certain important pipe lines; or what it cost to reblade the 500-kw. turbine, rebladed two years ago; or just what the figures were on that special high-priced oil test; or how the power-house expenses for 1914 compare with those for 1915? One of the best—and by that I mean one of the quickest, simplest and most convenient—methods of recording these and the many other valuable data that I have so far seen is the "operating-data" drawer in the office of a Boston engineer. The drawer in this plant is one of many in a common cabinet; but for most plants the dollar-and-something kind—one drawer, 14x5x4 in., in a wooden or steel casing by itself—fills the requirements. Filling the card is the work of but a few minutes, for things worth filing you have made note of at some time or other.

The more one gets around and the more plants one sees the more convinced he is that the chief—in most instances the sole—reason that so many engineers have no record of plant performances, cost or other data is because they never got started keeping any. Personal inertia, one might say. But once you get started, once you have overcome that inertia, you seem to get momentum enough to carry you on always. I cannot recall one engineer who ever got out of the habit of keeping plant data once he acquired it.

Just inquire into the value of such a file as the one shown. If you have not already, you will some time become convinced that it is not the best practice to make a gasket for an important joint by hammering it out on the flange on which you are going to use it. Would it not be better to get measurements of the flange, place them on file and cut gaskets during a lull? Suppose you have tested and tried a number of oils for a particular purpose and eventually found one most suitable, price considered. Assume further that you are later of-

Gaskets — Barometric Condensers

Large Flange on 30 in Elbow
- 44⅞ in. Dia. O.S.
- 37⅞ " I.S.
- 42 " Bolt Circle
- 32 - 1⅛ Bolts, 4⅛ t - t

Large Flange; Top of Cone
- 60⅝ Dia O.S.
- 53⅝ " I.S.
- 58¼ Bolt Circle
- 48 1" holes spaced 3¾ in t - t

Equipment Repairs
1910 – 1911 against 1911 – 1912

	Increase	Decrease
Boilers		
Boiler Settings		
Pumps		
Compression Machinery		
Absorption "		
Ammonia Condensers		
Brine Coolers		
Steam Condensers		
Piping		
Painting and Inspection		
Repairs, Machinery		
Repairs Misc.		
Engines and Generators		

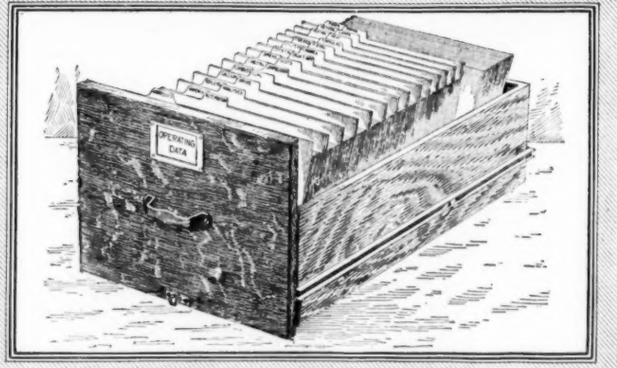
Pumping Engines, S.W. R.H.

	Gals.
No. 2 11½ in. plunger, total displacement – rod	52.12
Deducting 5% for slippage, net output =	49.51
" 3% " " " " =	50.55
" 2½% " " " " =	50.81
13½ in plunger, total displacement – rod	71.48
Deducting 5% for slippage, net output =	67.90
3% " " " " =	69.33
2½% " " " " =	69.69

Basis for figuring, 50.8 gal. for small one and 69.7 gal. for large one.

Analysis Coal 6/26/14

Name	Vol.	Moisture	Fix. Car.	Ash	Sul.	B.t.u.
Slab Fork	14.5	—	78.96	5.92	0.62	15,880



QUINCY MARKET COLD STORAGE & WAREHOUSE COMPANY

PRICE CARD

Goods, Etc. Turbine Repairs — 500 Kw.
Description Westinghouse Machine Co.

From Re-Blading Turbine No. 5	DATE	LOTS	LIST	DISC'T	NET
	9/30/15	Hours			
John Smith		173	125		$216 25
Expenses					71 20
John Doe		224½	40		89 70
Expenses					68 89
James Williams		224½	40		89 70
Expenses					68 51
O. Williams		140½	40		56 20
Expenses					45 85
W.L. Long		127¾	40		51 10
Expenses					38 48
Credit cost blading material returned — less return charges		114¾	40		45 90
	37.72 / 1.63				41 67
					$883 70

Test – Special High Test Ammonia Oil 4/2/14

Gravity	24
Flash	385 deg. F.
Fire	440 " "
Cold	+ 10 – 15° "
Viscosity	668 at 70 deg.
"	440 at 100 "

Power House Expenses
1910 – 1911 against 1911 – 1912

	Increase	Decrease
Coal		
Water		
Ammonia		
Calcium		
Oil		
Waste		
Carting Ashes		
Pay roll and Salaries		
Misc. (Packing, etc.)		
Equipment Repairs		
Repairs, Building		
Total		

Stirling Water Tube Boiler, No. 1

1 Unit, 189 hp.
Heating Surface 1892 sq. ft.
Grate " 40 " "
1 Feed valve and 1 check valve, 2 in. each
1 Faber blow-off valve, 2½ in. Dia.
1 Star Brass Steam gage, 12 in. Dia.
2 " " safety valves, 3 in. Dia. each
1 Reliance water column
Hoyt improved gage cocks
Eureka crank handle water gage
Piping, brass

SOME TYPICAL CARDS FROM THE "OPERATING DATA" FILE, QUINCY MARKET COLD STORAGE AND WAREHOUSE CO.'S PLANT, BOSTON, MASS.

fered an oil at a lower price and are given the test data and analysis. Unless your memory is extraordinary or you have a record of the analyses of the oils rejected during the past trials, how are you going to know without trial but what this newly offered oil is just like another you have tried and rejected? It should have been just as much your purpose in making those trials to know what not to get as to determine what was best to buy.

If increased load on the plant made it necessary to operate all boilers at 50 per cent. higher rating this year than last, how much more has it cost to maintain boiler settings this year than last? The management, or a visitor, or the firebrick people you deal with may want to know. How much quicker, how much more satisfied you would feel if you could reach over and pull out of a drawer a card bearing this information instead of bothering the bookkeeping or the auditing department and perhaps waiting a day or a week for the answer. Cards such as those above and below the file drawer shown carry a wealth of information when filled out. Of course if the bills and estimates do not pass through your hands, you are unfortunate. But if you could show the management your operating data file and let the boss see for himself that you were keeping tabs for the benefit of his plant, maybe he would begin to see that by such a system of recording and accounting you must eventually become, if you are not already, the best judge of estimates, materials and methods for the power end of the establishment.

Calculating Pumping Duty

By E. C. Doland

For the purpose of computing the number of gallons of water pumped for each pound of fuel burned, first find the displacement in gallons for one revolution of the engine; then the total displacement can be found by multiplying by the total number of revolutions as told by the engine counter. Knowing the number of discharging strokes per revolution, the diameter of the water plunger and the length of the stroke, the apparent displacement is found by squaring the diameter (in inches) of the plunger and multiplying by 0.7854, then by the stroke in inches. This gives the displacement of one stroke in cubic inches, which in turn divided by 231 (the number of cubic inches in a U. S. gallon) will give the apparent displacement in gallons of one stroke. Multiplying this by the number of discharging strokes per revolution will give the gallons per revolution, but as an allowance must be made for slip due to leakage of valves, plunger packing, etc., the actual output is found by multiplying the apparent displacement by 1 minus slippage loss in per cent., so the complete formula becomes

$$W = \frac{D^2 \times 0.7854 \times L \times N}{231} \times (1 - S) \qquad (1)$$

where

D = Diameter of water plunger in inches;
L = Length of stroke in inches;
N = Number of discharging strokes per revolution;
S = Percentage of slip;
W = Actual gallons displaced in one revolution.

The total revolutions in a given time multiplied by the output per revolution and divided by the total coal (in pounds) used for that time gives the number of gallons pumped per pound of coal, expressed as

$$\frac{W \times R}{C} = P \qquad (2)$$

W = Gallons per revolution;
R = Total number of revolutions;
C = Total coal in pounds;
P = Gallons per pound.

The duty of a pumping engine, or the foot-pounds of work done per 100 lb. coal or per 1,000 lb. steam, is

$$D = \frac{G \times H \times 10{,}000}{12} \qquad (3)$$

$$D_1 = \frac{G \times H \times E \times 1{,}000}{12} \qquad (4)$$

where

D = Duty per 100 lb. of coal;
D_1 = Duty per 1,000 lb. of steam;
G = Gallons pumped per lb. of coal;
H = Total head in feet on pump;
E = Evaporation; lb. of water per lb. of coal.

In this case G is found by formulas 1 and 2, omitting any allowance for slip on the pump as no allowance should be made for slip when computing the duty. H is found by adding to the discharge head in feet the suction lift in feet, or if the suction is under a head, it should be deducted from the discharge head to give H.

If the suction and discharge gages are not graduated in height readings, the head in feet can be found by dividing the pressure reading in pounds per square inch by 0.434, which is the approximate weight of a column of water 1 sq.in. in area and 1 ft. in height.

A gallon of water weighs 8⅓ lb., or 12 gal. to 100 lb. approximately, so the number 10,000 is found, allowing 100 as a multiplier for using the divisor 12 and multiplying by 100 for the coal, which is easier than to multiply the total number of gallons by 8.333 and then by the 100 pounds of coal.

Example: A triple-expansion pumping engine, with three 18-in. single-acting plungers 36-in. stroke, runs for 20,120 revolutions and the coal consumed is 3,300 lb.

1. Find the gallons per pound of coal.
2. Find the duty per 100 lb. of coal.
3. Find the duty per 1,000 lb. of steam.

Where

D = 18 in.;
L = 36 in.;
N = 3;
G = 725;
H = 230 (discharge head 215 ft., suction lift 15 ft.);
E = 9.6 lb.

1. $\frac{18^2 \times 0.7854 \times 36}{231} \times 3\,(1 - 0) =$ *App. 119 gal. per revolution*

2. $\frac{119 \times 20{,}120}{3{,}300} = 725$ *gal. per lb. coal*

3. $\frac{725 \times 230 \times 10{,}000}{12} = 138{,}958{,}333 =$ *Duty in foot-pounds per 100 lb. of coal*

4. $\frac{725 \times 230 \times 9.6 \times 1{,}000}{12} = 1{,}334{,}000{,}000 =$ *Duty in foot-pounds per 1,000 lb. of steam*

Standard Fuel-Oil Engine

SYNOPSIS—A horizontal two-stroke-cycle engine of the Diesel type employing a stepped piston for scavenging, a reciprocating cam for operating the fuel valve, an inertia governor and automatic control of injection air pressure.

Another Diesel engine of American design has entered the field. This is a horizontal single-acting two-stroke cycle type, built by the Standard Fuel Oil Engine Co., of Willoughby, Ohio, from designs of C. M. Blanchard. In general appearance it follows some previous products of the designer, but also includes a number of refinements. Its special features include a valveless cylinder, stepped piston for scavenging, cooled piston and automatic control of injection-air pressure.

As will be seen by reference to the illustrations, particularly Fig. 2, the frame is of the center-crank type and the construction compact and rigid. The cylinder for the scavenging piston is cast integral with the frame and encompasses part of the working cylinder. This incasing of the forward end of the main cylinder not only results in a more massive and rigid construction, but also gives a cylinder in which the wall is called upon to resist bursting strain only, thus permitting thinner walls and insuring more perfect cooling. The section through ports, being under practically no strain, can be cut up so as to secure the maximum of port area. Bolted to the side of the larger, or scavenging, cylinder is the two-stage air compressor, driven by a small crank on the end of the mainshaft. The first stage takes its air from the scavenging cylinder at about 5 lb. and delivers into tanks at 150 lb. for starting; from these tanks the second stage takes its supply and delivers direct to the fuel nozzle. By this arrangement air storage at extremely high pressure is avoided.

The front of the first-stage piston has an extension in the form of a piston valve (see Fig. 3) which controls the suction and discharge of the scavenging cylinder and also serves as a crosshead for the compressor.

The cylinder head is comparatively small and symmetrical, the inner wall forming practically a half-sphere. This feature is considered by the designer as considerable of an advance over what has heretofore been done when adapting the two-stroke-cycle valveless type to the Diesel principle. Instead of using the customary form of deflector on the piston, which gives an irregular form of combustion space, a cone shape is adopted for the piston end and the front end of the cylinder head is made to register closely with this; the result is that when the

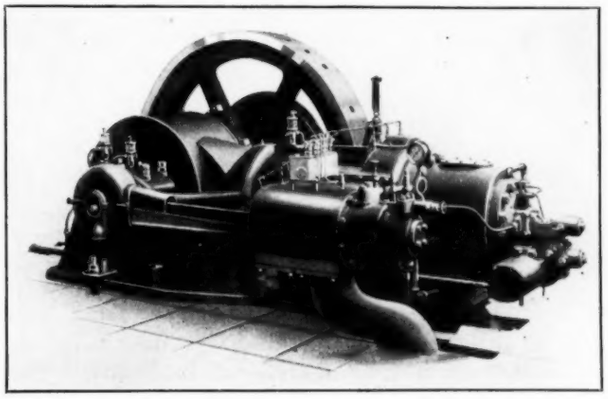


FIG. 2. GENERAL VIEW OF THE STANDARD FUEL-OIL ENGINE

piston is at the end of its compression stroke, the air for combustion is crowded into a chamber that closely conforms to the shape of the jet of fuel and air issuing from the fuel valve.

For deflecting the scavenging air toward the cylinder head end and away from the exhaust, not only the cone-shaped end of the piston is utilized, but also the bars in the inlet ports are so placed as to properly direct the course of the entering air.

There is only one opening in the cylinder head, which is for the fuel nozzle, this being placed in the exact center. The head is of course water-jacketed. The piston is also water-cooled—a somewhat unusual refinement for an engine of this size—water being taken in and discharged through the horizontal telescopic connection shown in Fig. 1. The piston pin is not subjected to very high temperature, since it is situated in the relatively cool differential piston. This location of the piston pin

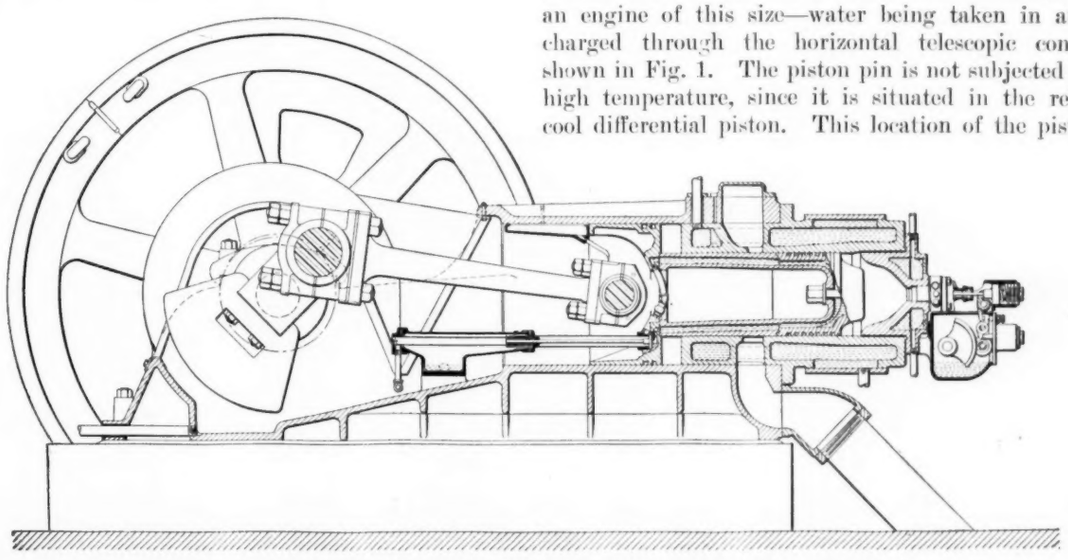


FIG. 1. LONGITUDINAL SECTION THROUGH WORKING CYLINDER

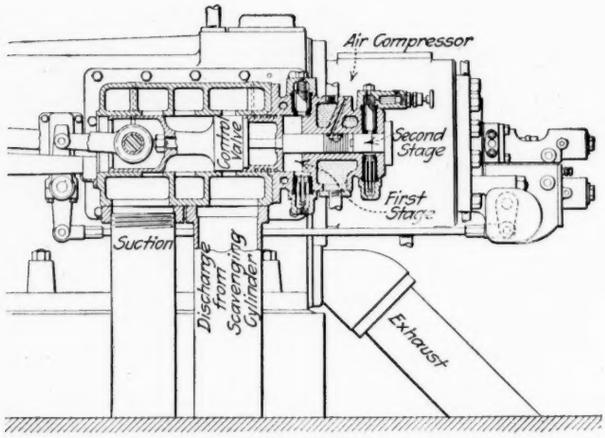


FIG. 3. SECTION THROUGH COMPRESSOR; ALSO SHOWING PISTON VALVE

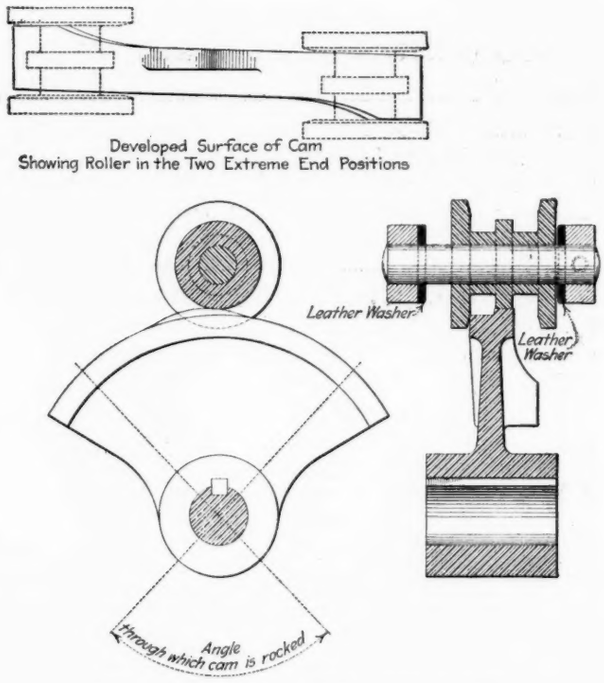

Developed Surface of Cam
Showing Roller in the Two Extreme End Positions
Leather Washer
Leather Washer
Angle through which cam is rocked

FIG. 4. CAM-OPERATING FUEL VALVE

also relieves the main cylinder wall of the connecting-rod thrust, as the differential, or scavenging, piston does the work of a crosshead. The pin is fastened to the scavenging piston by two studs passing directly through the ends.

As is common with the horizontal Diesel, the open type of fuel nozzle is used. That is, the oil is pumped into a small receptacle which at all times is in open communication with the combustion chamber, and when the air valve opens, this measured quantity of oil is swept into the combustion chamber. Since it is desirable to regulate the pressure of the injection air to suit the load, this has been taken care of by the governor which controls the amount of air admitted to the second stage of the compressor. In addition to this governor control, a choking control is provided in the suction line of the first stage of the compressor; this being effected by the pressure in the tanks.

A Rites inertia governor is provided and, besides controlling the injection-air pressure, varies the stroke of the fuel pump to suit the load.

Instead of the usual gears and side shaft, the fuel valve is actuated through a reciprocating cam which derives its motion from the compressor crank (see Fig. 3). As will be seen from Fig. 4, the cam roller, in addition to being lifted by the cam, is also pulled endwise by means of inclined surfaces on the sides of the cam operating against flanges on the ends of the roller, the result being one idle and one working stroke. In addition to eliminating gears, a side shaft with its bearings, etc., the designer also claims that with this arrangement the timing of the fuel valve is a less delicate operation than with the more usual type, as either advance or retardation of the timing or adjustment of the roller clearance is accomplished by turning a threaded screw.

Fig. 5 shows some indicator diagrams taken at various loads.

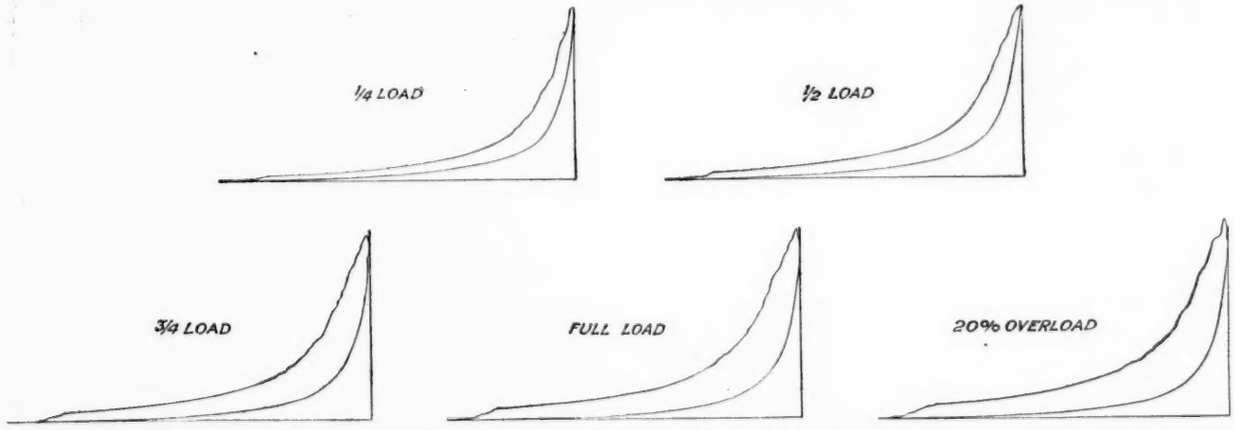
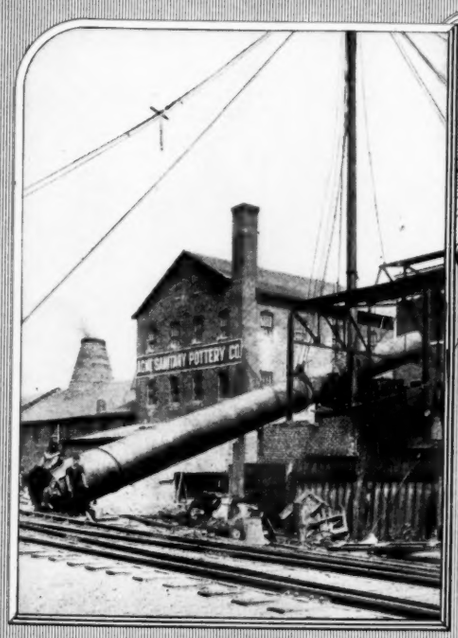


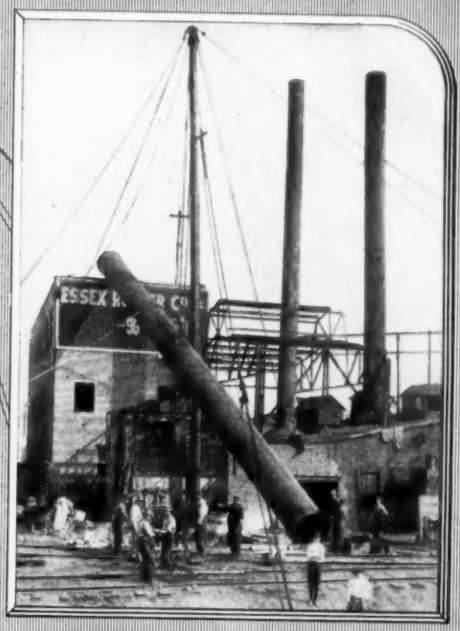
FIG. 5. SAMPLE INDICATOR DIAGRAMS AT VARIOUS LOADS TAKEN ON STANDARD FUEL-OIL ENGINE

When a Boiler Behaves Strangely it is too much to expect a man who has had no mechanical training to know what to do. Then, too, there is the risk of causing serious damage to a boiler by too rapid firing while the water is still cold, and many leakages and cracks are directly traceable to negligence in this respect. A temperature increase of 180 deg. F. causes steel to elongate $^1/_{1000}$ part of its length, and as the upper part of a rapidly heated boiler may be 270 deg. F. hotter than the bottom, it would be $^1/_{600}$ of its length longer than the lower part if it were free to move; but the upper part is linked to the lower part, and both are restrained from adapting themselves to the altering conditions, with the result that stresses are set up which may amount to as much as 10 tons per sq.in.—C. E. Stromeyer.

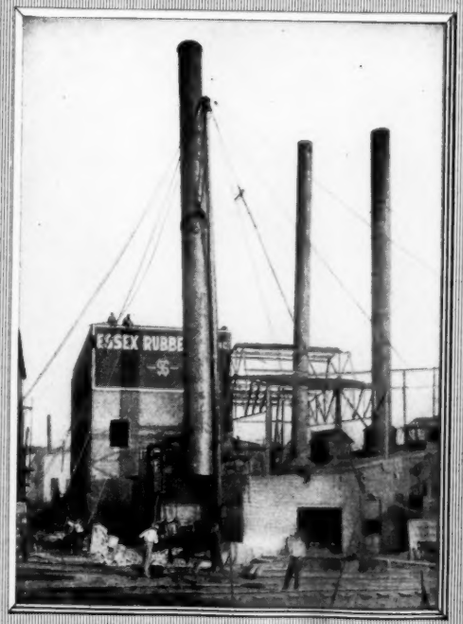
Stages in Placing a Steel Stack



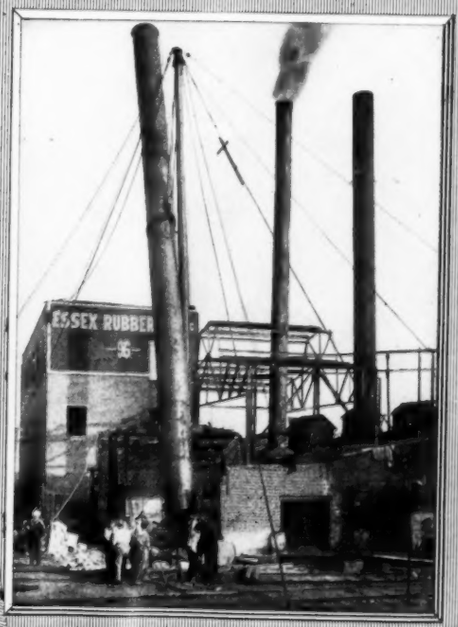
Stack Dimensions, 54 In. by 80 Ft.



Shifted Beyond Railway Track



Supporting Bridge 20 Ft. High



The Stack Nearing Final Position

Photographs Contributed by H. Brunner, Mechanical Engineer, Essex Rubber Co., Trenton, N. J.

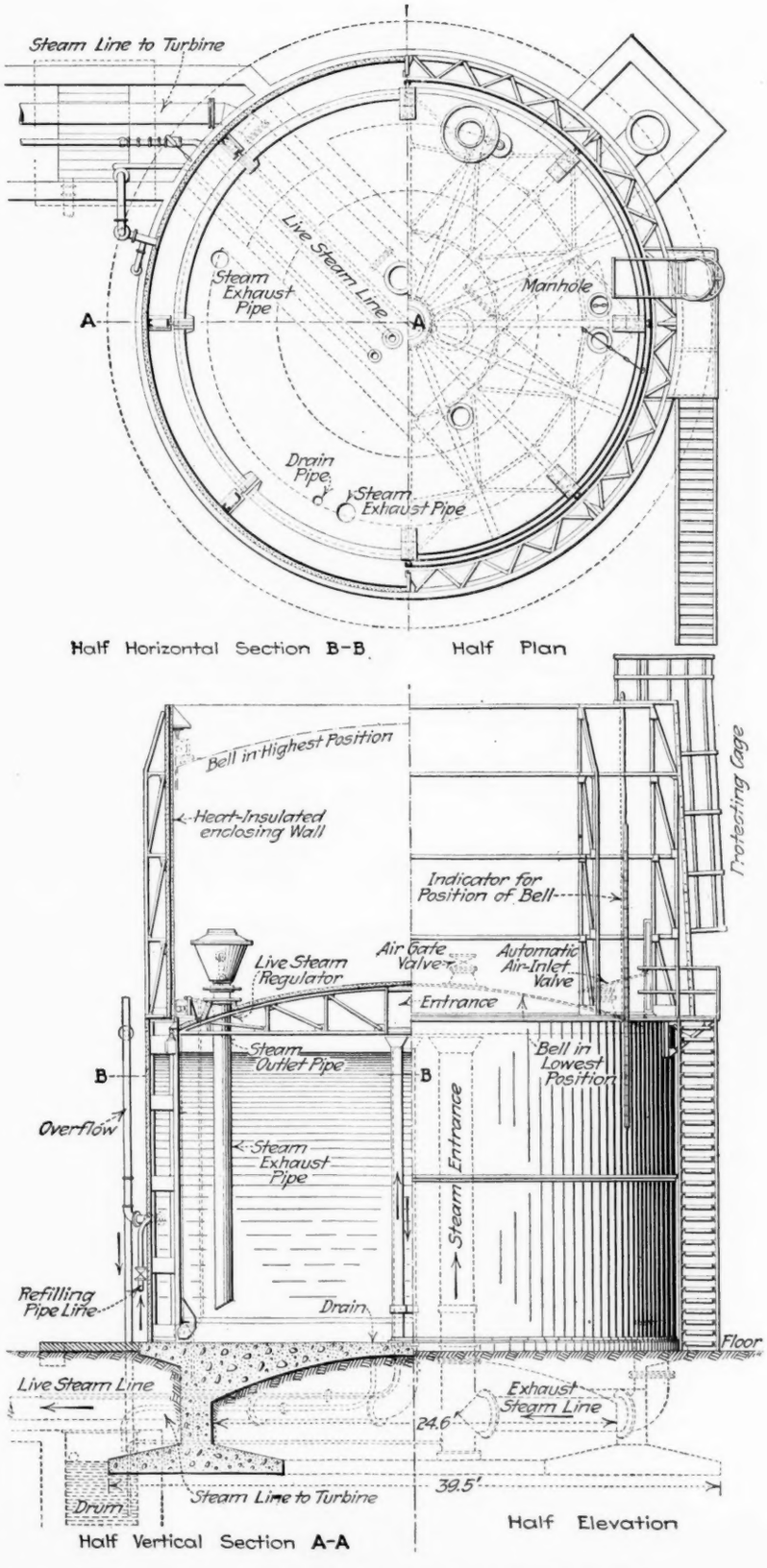
Gasometer for Exhaust Steam

If the use for exhaust steam synchronized with the supply, a great many problems would be simplified. Usually, however, the supply and the demand both fluctuate, and it is necessary to put some kind of an accumulator on the line to take up the surplus in times of excessive supply and to furnish the excess in times of more than average demand.

In Germany a bell holder is successfully employed for this purpose. The accompanying illustration, reproduced from the *Zeitschrift des Vereines Deutscher Ingenieure,* shows an installation, under the Harle-Balcke patents, in one of the mines of the Harpener Bergbau-Acktien Gesellschaft. It is designed to allow a variation in volume of 300 cu.m. (10,594 cu.ft.) and has the advantage over the generator in which the heat is taken up and given out by a body of water, that the back pressure on the engine does not need to exceed three or four hundredths of a pound above that of the atmosphere, which has no measurable effect upon the steam consumption of the attached engine or turbine.

The inverted bell moves in a container filled with water to seal it against the atmosphere, and is provided with an escape valve to release the steam when the bell reaches its highest position, preventing overpressure, and an inwardly opening valve to prevent the formation of a vacuum and collapse, should the steam supply fail. The maintenance of at least atmospheric pressure is further assured by the opening of a live-steam valve as the bell approaches its lowest position.

No information is at hand upon the question that will most naturally arise with regard to the use of such an arrangement—that of condensation. The article mentions that a protective wall has been built all around the bell so as to shield it in highest position, thus greatly diminishing the condensation, and says that this is a great improvement upon earlier installations, in which the insulating material was carried upon the drum itself; but no information is given with regard to the amount of condensation encountered. When the bell itself carried the wooden envelope which was used for protection against radiation, the hot water of condensation worked its way between the wood and metal, producing rapid corrosion.



A BELL GASOMETER USED FOR EXHAUST STEAM

Evaporation Corrected for Superheat

By R. T. Strohm

In a boiler trial in which the steam is superheated, it is evident that the usual method of determining the equivalent evaporation is inadequate, since it is based on saturated steam and therefore takes no account of the heat that is absorbed by the steam during superheating. If the superheating is done in a separate installation, not directly forming a part of the boiler being tested and using none of the heat generated in the furnace of that boiler, it should not be considered in determining the efficiency of the boiler, but if the superheater is an extension of the heating surface of the boiler and takes heat from the gases generated in the boiler furnace, it is necesary to determine how much heat is taken up by the steam after evaporation, so that the boiler and furnace may be credited with this heat.

The evaporative performance of a boiler is measured by the evaporation from and at 212 deg. F.; that is, it is necessary to find the number of pounds of water at 212 deg. that would be converted into steam at 212 deg. by the heat actually given up to the steam. For a boiler that generates dry saturated steam, the factor of evaporation that is found by the formula

$$F = \frac{H - q}{970.4}$$

in which

F = Factor of evaporation;
H = Total heat, above 32 deg. F., of 1 lb. of steam at the observed boiler pressure;
q = Heat per pound of feed water, above 32 deg. F.

When the steam is superheated, the amount of heat contained in each pound of the steam is greater than that in dry steam; consequently, the numerator $H - q$ of the foregoing fraction must be altered to include the heat absorbed by the steam in changing from the saturated to the superheated condition. This additional heat is the product of the weight of the steam, its specific heat and its rise of temperature; or, basing it on the pound as a unit,

$$c_p (t_s - t)$$

in which

c_p = Specific heat of superheated steam at constant pressure;
t_s = Temperature of the superheated steam;
t = Temperature of saturated steam at observed boiler pressure.

Letting F_s represent the factor of evaporation corrected for superheating, it follows that

$$F_s = \frac{H - q + c_p (t_s - t)}{970.4}$$

As $\frac{H - q}{970.4} = F$, this formula may be written

$$F_s = F + \frac{c_p (t_s - t)}{970.4}$$

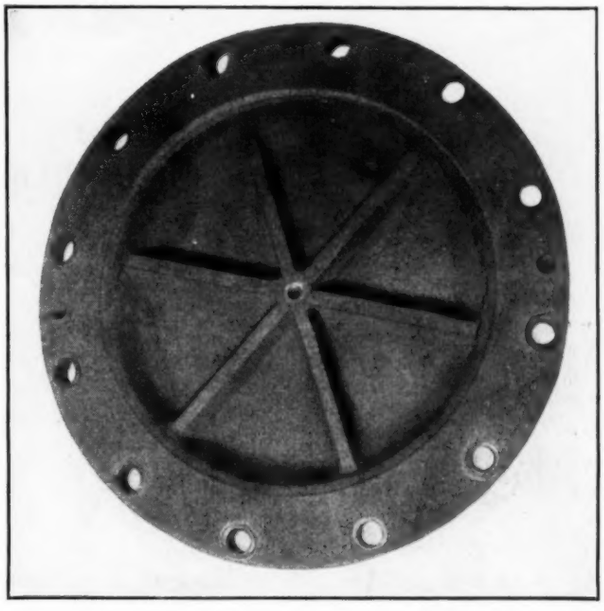
This signifies that the factor of evaporation, corrected for superheating, is equal to the sum of the factor of evaporation for dry saturated steam and another factor denoting the equivalent of the heat used in superheating. Inasmuch as there are in existence numerous tables of factors of evaporation for steam in the dry saturated condition at various pressures and with different feed-water temperatures, the last formula will be found useful.

Engine Cylinder Head Cracked by Gasket

By Charles F. Adams

On removing the false cover of the high-pressure cylinder of a 24x48x48-in. cross-compound condensing engine for inspection, the cylinder head was found with a crack extending around that part at the turn of the depression (see illustration). As the crack appeared to run parallel with the perpendicular face of the head, making it practically certain that the inner part could not be blown out, and as there was no steam leakage visible, the engine was continued in service for several days until a new head could be procured.

When the head was removed it was seen that the ¼-in. asbestos rope used as a gasket between the head and the cylinder had flattened to a thickness of about ⅛ in. under



SHOWING CRACK IN CYLINDER HEAD

the pressure of tightening the nuts and that it had become hard and unyielding.

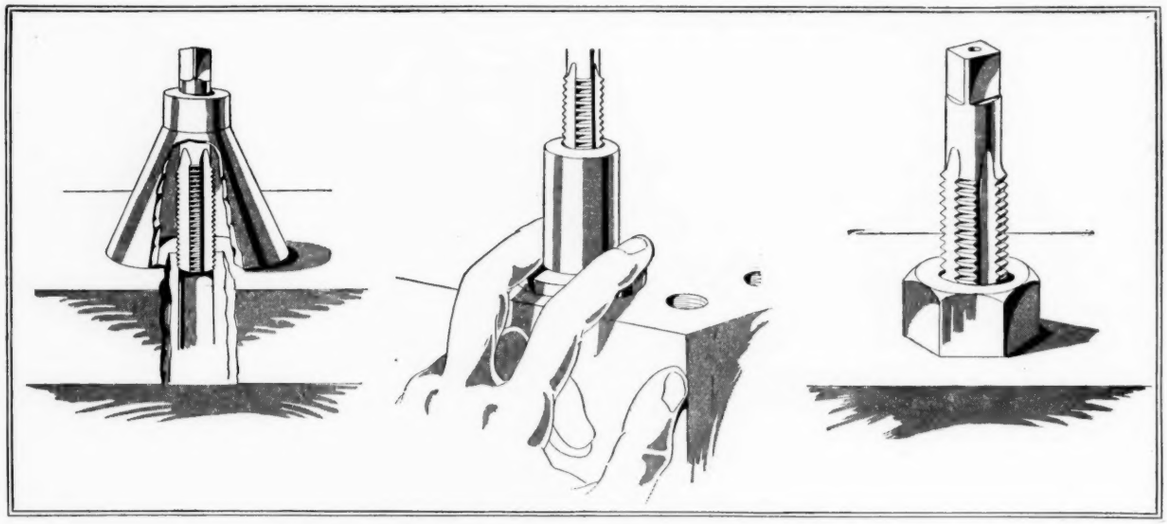
With the cylinder head in place and the gasket in contact with the end of the cylinder, a gap equal to the thickness of the gasket was left between the faced surface of the head and the end of the cylinder, and the pull of the nuts when drawing the head hard up to the cylinder is thought to have produced the stress that eventually resulted in causing the crack around the inner circle of the head, where the resultant of the leverage would be most effectively distributed.

The Swartwout Hydromatic Steam Trap

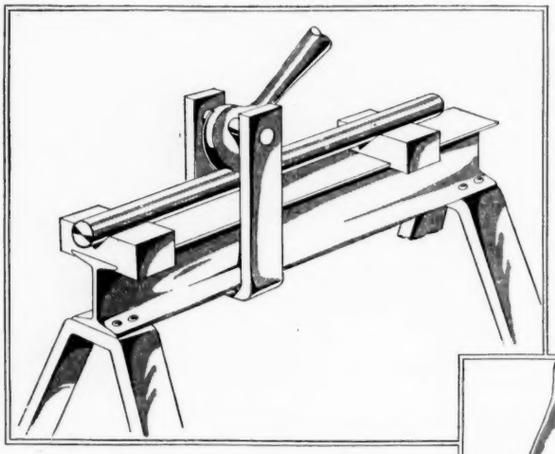
The Ohio Blower Co., Cleveland, Ohio, has taken over a new line of products to add to its line of Swartwout steam specialties. The most important of the new line is the hydromatic steam trap. It was formerly made by the Engineer Appliance Co. and was described in *Power*, Sept. 10, 1912, p. 403.

Two other devices added to the company's line are a water-level control valve and a low-pressure boiler feeder.

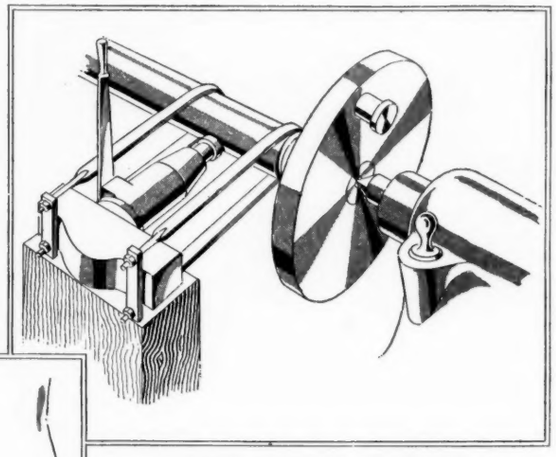
Handy Hints and Clever



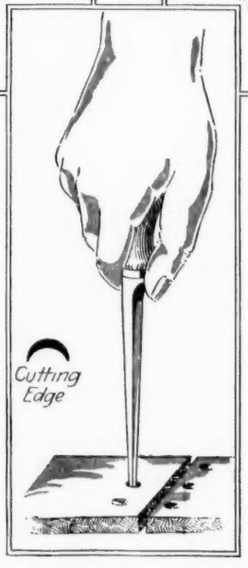
THREE DEVICES TO SQUARE UP A HAND TAP



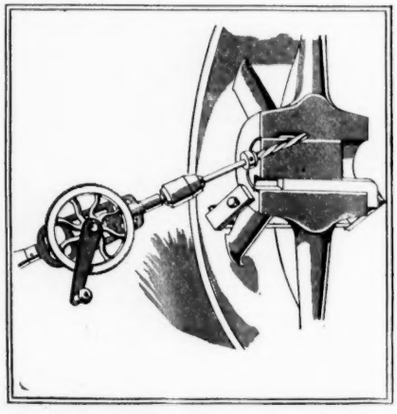
SHAFT-STRAIGHTENING PRESS



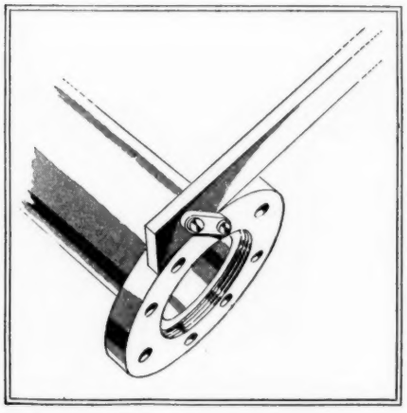
STRAIGHTENING A SHAFT



BELT PUNCH

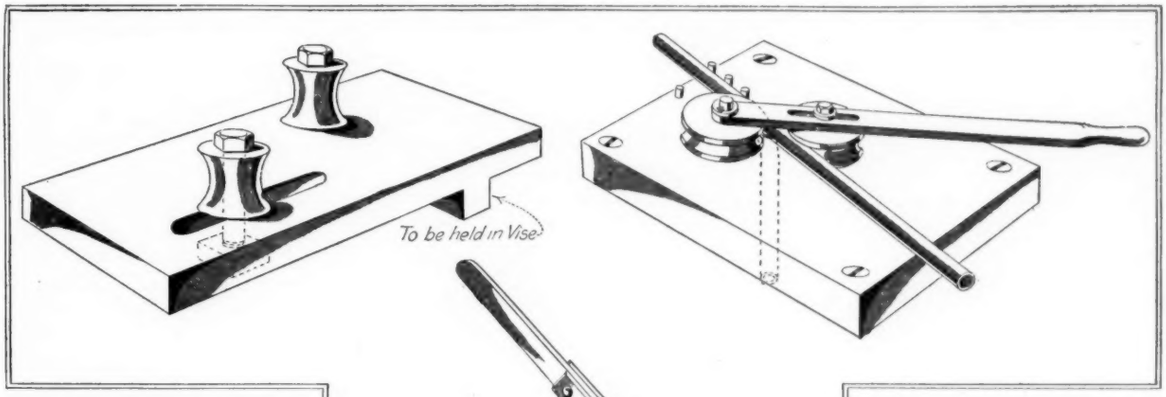


OIL-GROOVING DEVICE



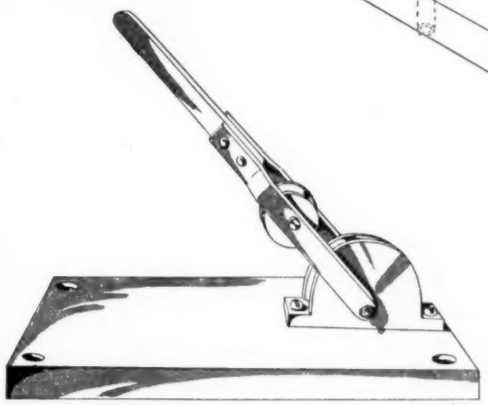
SIMPLE FLANGE WRENCH

Kinks for the Power Plant



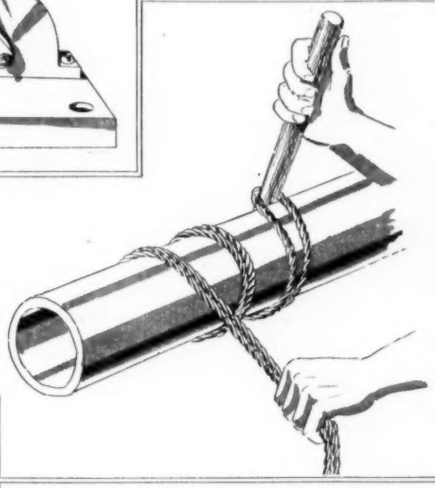
PIPE-BENDING FORM

PIPE-BENDING FIXTURE

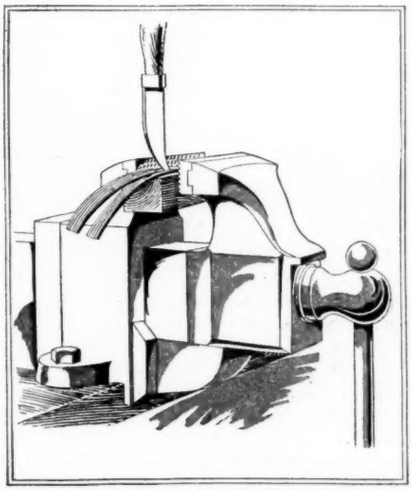


SIMPLE PIPE-BENDING DEVICE

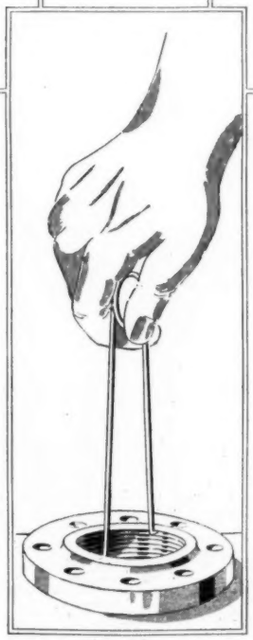
EMERGENCY PIPE WRENCH



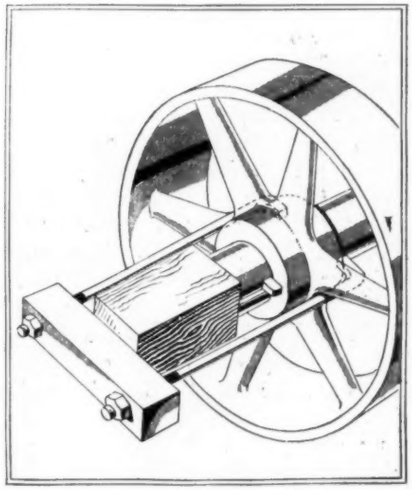
PIPE WRENCH FOR CLOSE QUARTERS



SPLITTING BELT LACE



SIMPLE THREAD CLEANER



PULLEY CLAMP

Buckeyemobile with a Uniflow Low-Pressure Cylinder

The Buckeye Engine Co., of Salem, Ohio, has built for the Dow Chemical Co. of Midland, Mich., a 75-kw., or 115-b.hp., Buckeyemobile, the low-pressure cylinder of which has a central exhaust upon the uniflow principle. The cylinders are 7½&16x17 in., and the speed is 225 r.p.m. The engine is directly connected to a Bullock direct-current generator. A plain piston valve with snap rings controls both inlet and exhaust of the high-pressure cylinder, but the low-pressure cylinder has a special valve controlling only the admission when running condensing and both admission and exhaust when running noncondensing.

The results of the acceptance tests were as follows:

ECONOMY TESTS—BUCKEYEMOBILE FOR DOW CHEMICAL CO.

	Test No. 1, A.M.	No. 2, P.M.
Date	Nov. 20	1915
Duration	4 hr.	4 hr.
Time	8 to 12	1 to 5
Indicated horsepower	115.96	133.69
Brake horsepower	101	115
R.p.m.	225	225
Steam pressure	224 lb.	224 lb.
Saturation temperature	396 deg.	396 deg.
Temperature at throttle	600 deg.	615 deg.
Superheat	204 deg.	219 deg.
Receiver pressure	16.5 lb.	22 lb.
Temperature steam to low-pressure cyl.	359 deg.	391 deg.
Low-pressure superheat	107 deg.	129 deg.
Final exhaust temperature	138 deg.	141 deg.
Feed-water temperature	124 deg.	124 deg.
Vacuum	22½ deg.	22 deg.
Stack temperature	500 deg.	
Total steam, lb.	4,829	5,403
Steam per hour	1,207	1,351
Steam per indicated horsepower-hour	10.4	10.1
Total coal, lb.	649	682
Coal per hour	162	170.5
Coal per indicated horsepower-hour	1.395	1.275

SUMMARY OF BOTH TESTS

Duration	8 hr.	
Total indicated horsepower-hours	999	
Total steam used	10,232	
Steam per indicated horsepower-hour	10.23	
Total coal used	1,331	
Coal per indicated horsepower-hour	1.33	
Guarantee	1.3	14,400 B.t.u. coal
Equiv. performance with 14,400 B.t.u. coal	1.28	

Coal Analysis per Dow Chemical Co.'s Letter, Nov. 23, 1915

Ash	11.74	Fixed carbon	70.48	Sulphur	0.56
Volatile	17.78	Moisture	2.16	B.t.u.	13,814

Suggestions to Young Engineers

By Lewis Lyne

One might conclude that all has been written that is necessary to know about engineering and practical problems in general, but it must be remembered that there are new generations making their appearance upon the engineering stage who have not had the experience of some of us older chaps in the trade, and these new fellows have to learn either by reading or from their own experience. The writer very early in life discovered that it was an excellent plan to get acquainted with the older engineers either in person or by their written work, and in that way he obtained some of the most practical ideas, which were put into use afterward.

Horatio Allen, who brought over and assembled at Honesdale, Penn., the first locomotive (the "Stourbridge Lion"), from England, ran it up and down the track a few times, was hence the first locomotive engineer in America. He was called upon for remarks before a class of young engineers, and in the course of his address he said: "Young gentlemen, never pass a scrap heap without investigating it, for you will bear in mind that until you have studied the scrap heap and find out where things break, you are not qualified to design machinery." I never forgot this simple injunction, and always, whenever opportunity offers, I take time to investigate the scrap heap; and, believe me, it has revealed some of the most interesting experiences and has proved the means of avoiding falling into faulty designs that would have proved expensive were it not for its revelations.

It often happens that a newly graduated college man, who is just bristling all over with original ideas, as he supposes, afterward finds that he has been digging over old ground, as it is natural that the same methods have repeatedly been tried to attain the same ends.

Cost of Station Spur Tracks

Among the items easily overlooked in estimating the cost of power-plant construction is the spur track. In some cases this includes a trestle for the gravity delivery of coal. In the following tabulation are given in round numbers, some recent costs of this kind for various lengths of track, drawn from a number of Massachusetts stations at which the outlay for track or trestle construction is available.

STATION A. TRESTLE AND SPUR; LENGTH, 778 FT.

(Construction: Timber on Concrete Piers. Trestle About 160 ft. Long.)

Excavation	202 cu.yd.	@	$0.50	$101
Concrete in piers and abutments	208.5 cu.yd.	@	5.75	1,199
Timber in trestle, including ties on trestle, 40 M bd.ft.		@	60.00	2,400
Ellis bumper (1)				70
Ladder (1)				4
Earth-filling	4,200 cu.yd.	@	0.31	1,302
Ties	314	@	0.59	185
Rails, 75-lb. T. (Laying)	778 ft. track	@	0.25	194
Rails, 75-lb. T	17.36 tons	@	30.63	532
Joints, continuous	52	@	1.64	85
Spikes	4.1 kegs	@	4.10	17
Teaming on track material	26 tons	@	1.25	32
Total				$6,121

STATION B. SPUR TRACK; LENGTH, 458 FT.

Grading	425 cu.yd.	@	$0.50	$212
Ballast	275 cu.yd.	@	0.75	206
Ties	229	@	0.52	119
Rail, 75-lb. T, 458 ft.	10.16 tons	@	28.54	290
Joints	20	@	0.88	18
Spikes	2.8 kegs	@	4.10	11
75-lb. split switch with frog No. 6				100
Track laying	458 ft.	@	0.25	114
Teaming on track material	23 tons	@	1.50	34
Total				$1,104

STATION C. SPUR TRACK; LENGTH, 693 FT.

Grading, earth	682 cu.yd.	@	$0.30	$205
Ballast, cinder	234 cu.yd.	@	0.25	58
Ties	304	@	0.51	155
Rail, 60-lb. T	10.79 tons	@	28.54	308
Joints	60	@	0.65	39
Spikes	4 kegs	@	4.10	16
Switches and frogs				202
Tracklaying	693 ft.	@	0.25	173
Teaming on track material	17 tons	@	1.25	21
Total				$1,177

STATION D. SPUR TRACK; LENGTH, 562 FT.

Ballast	73 cu.yd.	@	$0.75	$55
Ties	281	@	0.52	146
Rail, 56-lb. T	9.32 tons	@	28.54	266
Joints	24	@	0.62	15
Split switch and frog				75
Spikes	3.3 kegs	@	4.10	13
Tracklaying	562 ft.	@	0.25	140
Teaming on track material	12 tons	@	1.25	15
Total				$725

STATION E. TRESTLE AND SPUR TRACK; TOTAL LENGTH 394 FT.

Spur Track About 170 Ft. Long

Excavation	206 cu.yd.	@	$0.75	$154
Concrete	146 cu.yd.	@	7.00	1,022
Timber	64 M bd.ft.	@	45.00	2,880
Grading	204 cu.yd.	@	0.50	102
Ballast	23 cu.yd.	@	0.75	17
Ties, 8-ft. chestnut	85	@	0.54	46
Rail, 58-lb. T	6.70 tons	@	31.04	208
Switches and frog				105
Bumper (1 Ellis)				70
Joints	30	@	0.65	19
Spikes	2.1 kegs	@	4.10	8
Tracklaying	394 ft.	@	0.25	98
Teaming track material	24 tons	@	1.25	30
Total				$4,759

Editorials

The Municipal Power Plants of Western Canada

A perusal of the series of articles that have appeared recently in *Power*, describing the municipal power plants of some of the western Canadian cities, brings out a number of unusual ideas in regard to the management of public-owned utilities. All the plants described are of recent construction and have been built along modern lines with uptodate and efficient equipment. The unforeseen growth of some of the cities made imperative the purchase of increasingly large units, for which in many cases the plants were not originally designed. Yet good judgment has been shown in adapting plants to the altered conditions. While some of the stations retain old equipment still ready to serve, it is seldom used except on peak loads or in emergencies.

The importance of economical operation is amply realized by those in charge, and aids to the attainment of efficient results are in general use. Such devices include CO_2 recorders, V-notch recorders, coal-weighing devices, recording thermometers, steam and water-flow indicators and adequate systems of records. In some plants the monthly records are posted in the boiler room where the firemen can see for themselves what results they are obtaining. Such a system encourages the workmen to put forth greater efforts.

In several cases the electrical service to consumers has to bear heavy capital charges, owing to the fact that old equipment was discarded before sinking funds had retired the debentures originally issued to cover it. Thus consumers are forced to pay charges on both old and new debenture issues. But in spite of these handicaps the rates for municipal power in general are as low as, if not lower than, in most cities of the East and even of the Middle West. This difference becomes of greater interest when one recalls that labor in the Canadian West is invariably more expensive than in the East. These low rates are not quoted at a loss to the municipality, for each utility showed a surplus over all costs even in the war year 1914. Furthermore, it is now becoming a general practice to set aside depreciation funds which, together with sinking funds, will meet all replacement charges, although the sinking fund itself should take care of depreciation as applied to plant used up.

One cannot refrain from expressing a word of appreciation for the splendid service rendered by the engineers and superintendents of these plants, for the results they have obtained and for the vigor and aggressiveness with which they attacked the new problems that were continually confronting them. It is necessary to remember that such good showings were largely, if not entirely, due to the initiative and personal ability of the engineers. In municipal service employees are usually not subject to such pressure and prodding from executive officials as when employed in privately owned plants. It is further evident that politics must have played a very small part in the operation of these plants, for otherwise costs could not have been kept down to such figures as to make the current rates possible.

There is a tendency toward municipal ownership and operation in many American cities. While this editorial is no brief in favor of this movement, it is but fair to call the attention of engineers to the facts and figures of these Canadian undertakings as set forth in recent articles. In the ultimate analysis the success or failure of municipal enterprises is largely a matter of the personnel of the staff and of competent counsel in connection with its organization, together with the measure of freedom of the utility from political interference. The Canadian cities appear to have been exceptionally fortunate in regard to these necessary fundamentals.

Hydro-Electric Power and Large Industries

That cheap water power in large quantities is necessary to the existence of certain industries, some of which would serve the preparedness issue by rendering this country independent of outside sources of supply, was well brought out at the recent meetings of the American Institute of Electrical Engineers and the American Electrochemical Society in Washington. The program was arranged, apparently with the twofold purpose of pointing out the dependence of the electrochemical industry on water power and thereby inducing Congress to take a more favorable course. As the discussion progressed, however, it became apparent that, in spite of many accusations, Congress is not alone to blame for the present state of water-power development. There are other factors sharing the responsibility—some economic, some engineering—among which may be mentioned, briefly:

1. That water-power development as concerns large industrial applications, such as electric furnaces and the production of nitrogen, is in a class distinct from that of public-utility service. In the former the load factor is high and the power must be continuous and cheap, since the power cost represents a relatively large proportion of the cost of the finished product.

2. In public-utility service the load factor is comparatively low, and as pointed out by Mr. Scott, with load factors below sixty per cent. the modern steam plant can beat out the hydro-electric plant in the East.

3. Geographical location also has important bearing. There is an over-development of hydro-electric power in parts of the West, and the transportation charges on both raw material and the finished products to the Eastern markets have figured largely in non-utilization of this power for large industrial undertakings.

4. It was argued that large installations for the fixation of nitrogen from the air have located in Norway in preference to the United States. This has probably been due more to the extremely high heads there available, meaning smaller investment charges and consequently cheap power, and to their location near the coast, than to governmental policies.

5. There have been many failures in hydro-electric work, due sometimes to lack of foresight as regards the market for electricity, in other cases to engineering mistakes and in still others to unforeseen obstacles.

As concerns the attitude of Congress, the case narrows down to the charge that with the restrictions imposed by pending legislation it would be impossible to attract the necessary capital to such developments. However, if it were not for our "wasteful methods of financing," as one speaker put it, the restrictions would not be so burdensome. In addition to the high physical cost incident to most hydro-electric developments, the promotor desires a handsome profit and the banker must have his share, the stock ultimately being unloaded on the public at an inflated value, which requires high power rates to net a reasonable return.

While it is perhaps true that some members of Congress are prone to see only one side of the question, still it must be remembered that they are not only intrusted with a duty of safeguarding the present interests of the public, but must look to the future as well. Congress could perhaps afford to be liberal with the present situation, but must look forward to the time when coal and oil will have been nearly exhausted; at which time competition from these fuels will have been removed and unless the Government is then clothed with adequate powers, both large and small industries will be at the mercy of those in a position to dictate the terms.

⁂

Living Down an Error

While it has been well said that the man who makes no mistakes never makes anything, it is most emphatically the business of the operating engineer to do enough thinking before he acts to keep his record as nearly perfect as is humanly possible. The responsibilities of such work are too serious to allow errors to be regarded lightly. When an engineer has the misfortune to make a mistake in his work, one which happily results in no personal injuries or serious damage to the plant, but one which inevitably lowers his standing with his superior, how can he best "live down" the occurrence?

Assume that the engineer has prepared an estimate of the cost of remodeling one section of the plant into a pumproom and of adding one or two units of increased efficiency instead of trying to keep along with the existing equipment, and suppose that when the figures are checked it turns out that the yearly cost will probably be thirty per cent. higher than the engineer allowed, owing to a mistake in computations. When the owner finds the error, it may appear to be too late to change the plan, in view of contracts having been signed and the equipment shipped. Then the only thing to do is to go carefully over the figures and to see first of all whether the difference really alters the conclusion which should be reached in a proper engineering solution of the problem. It may be that the day is not wholly lost; that by going over the guarantees and local conditions with a brother engineer, it can still be shown desirable to make the change. If this is so, the engineer is more fortunate than if his error has led the plant owner to a wrong conclusion, for it will not take as long to reestablish confidence.

But whether through good fortune or not, the engineer's employer continues to hold him in high professional regard, the man who makes an error on the right side needs to be just as careful to avoid its repetition. An error is an error, no matter who makes it, and every mistake, no matter how small it may appear, should be faced and its lesson learned. It takes courage to walk up to the office and say that an error in computation (perhaps one that a grammar-school boy would be disciplined for committing) will throw out the validity of the recommendations previously made, and yet the broad-minded, sympathetic superior will thank a man for coming frankly to him in such an event. Often it is possible for men who have done business together for years in the purchase of equipment to agree at once to cancel contracts and save the chances for a better arrangement of equipment. Anyhow, it is the plain duty of the engineer to lose no time in giving his superior a chance to rectify affairs, and that is the first step toward living down an error.

The engineer who has made a slip can only resolve by hard work never to be caught in any such mistake again. He will take time enough to check his figures after this before submitting them to the man above and will not assume responsibility for them if insufficient time is granted for reasonable checking. This is not the worst, however. Often the hardest thing about making a mistake is that it frequently prolongs for months the probation period in which the plant owner refrains from giving the engineer a second chance of the same kind, and perhaps calls in someone else to give advice, who the engineer knows is less competent than himself to pass judgment. Fortunately for most of us, the flies we muff do not decide the World's Series, but in striving for that accuracy which is the just glory of the engineering profession in all its branches, a "fielding average" of one hundred per cent. should be the yearly ideal of every ambitious operating man.

⁂

Alas! Thus do false rumors penetrate all cautious guards and make us weep when their real nature is exposed. In the April eighteen issue an item stated that the bill to insert a penalties clause in the New Jersey license law and to increase the examiners' salaries had passed over the governor's veto. Unfortunately, later advices show that it failed to pass by a few votes.

⁂

Doesn't it make an engineer proud of his experience to specify this or that and have the purchasing agent order something else?

⁂

Five Men Burned in Polar Wave Ice Plant.—Headline. Another reputation ruined.

⁂

We wonder how many good engineers have been lost to the calling because their early ambitions were callously thwarted by managers who regarded them as evils expedient to tolerate.

⁂

You still have plenty of time to arrange to take air for combustion from above the boilers and place a cold-air duct with outlets over the firing aisle before it's ninety on the street and goodness knows what in the boiler room.

⁂

Remember, low uptake temperatures do not mean much if there's a hole as big as a scoop in the breeching.

Correspondence

Soot and Its Formation

I am sure that while many engineers realize that soot is a foe to efficiency, they do not fully appreciate how a thin coating of it prevents the transmission of heat in the proper quantity necessary to getting the rated capacity out of the boilers. This fact was brought home to me very forcibly recently. One of the younger engineers in my family borrowed from one of his neighbors a toy upright boiler with an engine attached and had to have an immediate demonstration. I filled the boiler and placed it over the burner on the gas range and in a few minutes had steam up, the little engine running and the tiny whistle blowing. Soon the engine showed signs of slowing down, and I turned off the steam from the whistle to have all available to speed up the engine; but it seemed to run slower and slower. I turned the gas on as strong as the single jet could flow and the engine ran swiftly for a few minutes more and then gradually got slower and slower.

I thought all of the water had been evaporated, but was surprised to find that the boiler had plenty in it. Upon further investigation I discovered the shell of the boiler had quite a coating of soot. After I brushed it off, the engine was hard at work in about a minute.

These few minutes spent playing with a child's toy showed me that soot is one of the most effective non-conductors. The old-style hit-and-miss method of removing soot from the boiler by the hose and nozzle or steam lance is still the usual method, but I feel that the engineers are partly to blame.

If owners were ever forced to climb up on a shaking temporary platform on a July day with the temperature 125 deg. near the boiler front, and stand up and "punch" the flues with a hand blower, they would appreciate that the conditions are such as to dishearten a man so that he does not care whether the tubes are well cleaned.

Louisville, Ky. EDWARD J. MCDONOGH.

Wooden Feed-Water Heater

In the issue of Feb. 15, page 230, H. R. Rockwell tells of a wooden feed-water heater and asks to hear from *Power* readers who have seen such contrivances. Following is a description of one used in an out-of-the-way plant some time ago. It was made in about the same manner as the one that was shown. The dimensions were 2x2x6 ft., and it contained about 180 ft. of 3-in. pipe for the coils, joined together with close return bends. Space in the engine room being limited, the heater was placed outside and the exhaust entered at the top of the box and passed out at the side; and as the main-line water pressure was 275 lb., no pump was required to force the water through the coils and into the boiler.

The apparatus easily supplied two 50-hp. boilers with water that entered the heater at about 50 deg. and passed out at 190 deg. or more. A valve was placed on the high-pressure water line to regulate the amount passing through the heater, thereby keeping the coils under boiler pressure only. A gage placed between this valve and the heater aided greatly in regulating the feed. All the exhaust from a 14x16-in. air compressor was passed through the heater. No trouble was experienced with the device in any way, and it certainly saved a lot of fuel. We were burning wood that cost $7 a cord, and before installing the heater, 5 cords were used per 24 hr. Afterward ½ cord was saved. LOUIS VOZZA.

Surf Inlet, B. C.

The illustration shows a feed-water heater on a par with the one described on page 230, of the Feb. 15 issue. It was made out of a large barrel and sundry wreckage from

FEED-WATER HEATER MADE OF WASTE MATERIAL

the junk pile. *A* is the cold-water supply on which is an old whistle valve *B* with the spring removed, operated by the float *C*, formerly the guardian of a closet tank; *D* is a discarded sprinkler head from a shower bath; *E* is the exhaust pipe and *F* the hot-water supply to the boiler-feed pump; *G* is shelving made out of the lining of an old flour reel held in place by stayrods *H*; *I* is the overflow and surface skimmer pipe at the high-water level *K*.

"Where did you get the idea of the heater, Mike?" I asked. "You remember," he answered, "when I was firing at the Rapid Transit plant some 30 years ago, we had a heater on the same principle filled with hay, only it was all made of iron and had a lot of 'gingerbread' arrangements on it and a glass gage to show the water level, etc. My barrel heater does the work if not much for looks."

Memphis, Tenn. W. B. SHIPPERSON.

Commends Grooved Cylinders

Some time ago (Dec. 7, 1915) there appeared in *Power* a discussion of the subject of grooving cylinders to act as oil channels to improve lubrication. The method is excellent and should be generally adopted.

One of our high-speed units was rebored and the cylinder grooved in the summer of 1909. This engine has an average daily run of 18 hr., and the cylinder is in excellent condition today. The grooves are about three to the inch and cut not more than 0.007 in. deep.

On starting up after the grooving was finished, the cylinder groaned for several days and then gradually ceased. The grooving today is plainly visible and shows little wear after six years' service. Our other high-speed engines are to be rebored soon and will be grooved in the same manner.

R. L. GARMONT,
Engineer, Union Club.

New York City.

Notes on Surface Condensers

The "Notes on Surface Condensers," by A. B. Clark, in the Mar. 28 issue of *Power,* are interesting, but the article would be more valuable if the author had given the derivation of the several constants used. He says:

"The heat that it will be necessary to extract per pound of steam condensed is about 930 B.t.u."

"To transmit this heat from the steam to the inside wall of the tube requires a temperature head of 1.08 deg. F. per 1,000 B.t.u. transmitted per square foot per hour."

"To transmit the heat from the tube to the cooling water if the water velocity is 3 ft. per sec., the temperature head will be 7.15 deg. F., but if the water velocity is increased to 5 ft. per sec., the temperature head is only 4.3 deg. F."

How are the figures 930, 1.08, 7.15 and 4.3 obtained? The figures at the bottom of page 438, 7.23 and 11.43, should be 17.23 and 12.43 if the figures preceding them are correct.

WILLIAM KENT.

New York, N. Y.

In answer to Prof. William Kent, I would like to say that the article was not meant to go deeply into the matter under discussion, but to give curves, so that the engineer in charge of a plant can check up the performance of his condensers correctly. The curves are for use with modern condensing plants working in conjunction with large turbines. With 200 lb. steam pressure at the stop valve, 150 deg. F. superheat and 1 in. of mercury absolute exhaust pressure, the water rate is about 11.5 lb. per kw-hr. for large machines. One kilowatt-hour is equivalent to 3,412 B.t.u., but as the turbine has to make good the losses due to the electrical generator as well as its own mechanical efficiency, the work required to be done to obtain 1 kw.-hr. at the generator terminals is equivalent to 3,630 B.t.u. This corresponds to an over-all efficiency of about 94 per cent. With a water rate of 11.5 lb. per kw.-hr., the heat converted into work per lb. of steam is $3,630 \div 11.5 = 315$ B.t.u. The total heat in 1 lb. of steam at the stop-valve conditions is 1,285 B.t.u. Therefore the heat in 1 lb. of exhaust steam is $1,285 - 315 = 970$ B.t.u. The temperature of the condensate is about 72 deg. F., containing 40 B.t.u., consequently the heat given to the cooling water per pound of steam is $970 - 40 = 930$ B.t.u. Of course this figure of 930 is not absolutely constant, because the vacuum is not always 1 in. of mercury, absolute, but if the absolute pressure is lower, the water rate of the turbine is better, with a corresponding increase in the heat converted into work, giving less heat in the condensate, as it is colder. The net result is that the figure of 930 B.t.u. is not materially altered. A change in absolute pressure in the opposite direction gives a similar result.

To answer Professor Kent fully on the other points raised would require a number of papers on the subject, of a technical nature which might not be readily followed by everyone. I would like to say, however, that the figures arrived at are largely from experiments carried out on condensers or on single-tube condensers connected thereto, also from physical experiments by myself and by others.

Perhaps it is hardly necessary to point out that as the velocity of the water increases through a condenser tube, the flow becomes turbulent, resulting in a greater heat transfer for the same temperature head. Also, turbulent flow is obtained in a tube of large diameter at a lower velocity than in one of a smaller diameter, hence the advantage of the larger tube. The inconsistencies mentioned at the end of Professor Kent's letter were typographical errors.

A. B. CLARK.

Chicago, Ill.

Galvanized Pipe for Ammonia

In the Mar. 21 issue Thomas G. Thurston asks to have the subject of galvanized pipe for ammonia discussed.

While in charge of a large cold-storage warehouse in an Ohio city, I had about 7,000 ft. of 2-in. direct-expansion piping to install, and to avoid rusting and odors due to painting, I determined to use galvanized pipe. I was not aware, nor were operating men with whom I talked, that ammonia had any deleterious action on galvanizing, so extra-heavy galvanized piping and the necessary valves and fittings were ordered. We had always had success in this plant, but soon trouble started. The head pressure went up to the limit and compelled shutting down, as it seemed that oceans of water would not keep the condenser pressure down. The condenser was of 125-ton capacity, counter-current, though there were only 75 tons of compressor capacity in that part of the warehouse. We purged and purged, as the gases seemed to be coming constantly. Getting down to normal pressures, we started again only to find that we could get nothing but liquid to the compressor. Operating slowly and with the suction valve cracked, we finally got some kind of service. Suddenly up went the condenser pressure again, and more purging followed. We purged frequently night and day for a week. We managed to keep nearly normal temperature in the cooler, and we finally got down to regular operation again. I sifted the matter and finally blamed it on the galvanized piping.

I had not charged any ammonia into the system since putting in the galvanized coils, but had charged three days previously and had been operating all right.

The pipe and fittings were galvanized on the inside, and the ammonia probably dissolved the galvanizing and in doing so formed a gas. The system contained considerable oil, and this no doubt had contributed to the trouble. Finally the trouble ceased, evidently when the galvanizing was gone.

Something else happened to me once that is interesting. I had 50 drums of ammonia of one make in the system, and charged 10 drums of another make that was represented as being much purer and better. Immediately the battle for supremacy began. Slugs of liquid came to the compressor and we had to stand by for 30 hr. Suddenly the rod would get hot, and as quickly it would get cold. I have no intention of mixing different ammonias again, not in such large proportions at once. To avoid the trouble, I would charge slowly, stopping to observe the effect before putting in more ammonia. Also I would watch the suction valve or have a reliable helper do so. D. L. FAGNAN.

New York City.

Heat Maladies of Marine Diesels

Mr. Illmer's letter in the Apr 11 issue is interesting but somewhat misleading. In the first place he refers to the "Hagen" and the "Loki" as being repeat orders, also the "Wotan" and "LaFrance."

This is not the real fact, because the "Hagen" (now renamed "Glenpool") and the "Loki" were, with a third and larger ship, ordered together by the German branch of the Standard Oil Co., and the "Wotan" and "LaFrance" were ordered by two other subsidiaries. The engines of the "Wotan" were built by the Reiherstieg Co. and those of "LaFrance" by Schneider & Co. Although, in the latter two instances the primary designs were by Carels, the general arrangements of the engines were quite different. So in no sense can these ships be called repeat orders, hence the original statement made by Mr. Crowly was perfectly accurate and fair.

It may interest Mr. Illmer to know that the Flower Motor Ship Co. ordered, at one time, three two-stroke-cycle-Diesel-engined ships, namely, the "Abelia," "Arum" and "Arabis." The first-named was torpedoed and sunk shortly after being placed in service. The other two were returned to the builders because of their unsatisfactory operation, the builders agreeing to run these ships themselves and pay the owners 5 per cent. per annum on the cost of the ships. The British Admiralty has since taken over these two ships, paying 4 per cent., and is using them for making short submarine-scouting trips in the North Sea—work for which they seem best fitted.

Also can Mr. Illmer point out a single case of where a two-stroke-cycle-Diesel-engined mercantile ship of over 500 b.hp. per shaft has made a continuous run at full load for ten 24-hr. days? Four four-stroke-cycle type motor ships have made nonstop voyages of 40 days and over, one being a 65-day voyage. Even on these voyages the engineers stopped the engines, (one at a time) after about 20 days' running to clean the piston rings and fuel-injection valves.

As regards the Navy Department being in favor of the two-stroke-cycle engine, this is inaccurate, because the engines of the "Maumee" were ordered against the advice of important officials in the Bureau of Steam Engineering and before the working of two-stroke-cycle-engined ships at sea had shown the weakness of this type. Furthermore, a week before the bids for the last batch of submarines were ordered, the specifications were altered to read: "Four-stroke-cycle engines preferred, but two-stroke-cycle engines will be given consideration." The writer personally saw this clause in the specifications.

Recently, before the Naval Board, Rear-Admiral Grant stated (according to the New York *Sun*) that "Our entire trouble has been with the two-stroke-cycle engine of the Nurnberg type. Germany is having much less engine trouble than the United States, because it uses the four-stroke-cycle type of engine, and in the twelve boats built at Quincy for Great Britain, of the same general type as our H submarines, the four-stroke-cycle engine has been installed."

Again, is Mr. Illmer aware that at the Augsburg works of the Maschinenfabrik Augsburg-Nurnberg, (where Doctor Diesel originally developed his engine in conjunction with Mr. Lauster, the chief engineer) they have persistently refused to abandon the four-stroke-cycle in favor of the two-stroke-cycle, and that all the engines built by this firm for the German Navy are of the former type? Only Krupps produced a satisfactory two-stroke-cycle engine by making it of bronze at enormous cost.

Finally I might add that the Standard Oil Co. is seriously considering removing the two-stroke-cycle Diesel engines from the "Glenpool" because their service does not warrant their retention as propulsive power.

New York City. F. O. LISLE.

Flexible Coupling on Turbine Governor Breaks

Your editorial suggestion that engineers begin to discuss their turbine troubles and their methods of correcting them was timely.

Some two months ago the flexible coupling on our 600-kw. turbine governor broke. Upon investigation the driving end of the shaft and the end to be driven were found to be 0.065 in. out of line. We lined them to 0.010 in., allowing this much owing to the fact that when the machine warms up, as when in operation, the expansion will be sufficient to correct this error.

A new coupling was then placed in service. This for a starter; who will be next? T. J. CRAVEN.

Waycross, Ga.

Cylinder Lubrication Question*

I have been reading the discussion of cylinder lubrication for some time, and perhaps a statement as to the performance of the plant under my charge will not be amiss. As stated, the only basis for comparison is in feet of piston travel per minute, size of cylinder and moisture in the steam.

We have two 22x36x22-in. cross-compound and two 18x18-in. simple Skinner engines and one cross-compound two-stage air compressor, size 18 and 30 steam by 26 and 16 air by 24-in. stroke. The high-pressure side of one of the large engines (22-in. bore) is lubricated with a fraction over 2 pints per 12 hr. with a piston speed of 550 ft. per min. The low-pressure side (36-in. bore), having the same piston speed, is lubricated with $1\frac{1}{7}$ pt. per 12 hr., making a total of a little less than $3\frac{1}{3}$ pt. per 12 hr. The other unit of the same size does slightly better; to be exact, it runs and is perfectly lubricated on 3 pt. per month less.

*Other discussion on this subject will be found in the issue of Feb. 22, page 266. Another series on a similar subject, "Cutting Down Cylinder Oil," appeared in "Power" Nov. 2, 1915, p. 602; Nov. 30, 1915, p. 673; Jan. 4, 1916, p. 23; Jan. 11, 1916, p. 53 and Mar. 28, p. 447.

The small engines (18x18-in.) have a piston speed of 675 ft. per min. and run on 12 pt. per month each, or slightly more than ½ pt. per 12-hr. run.

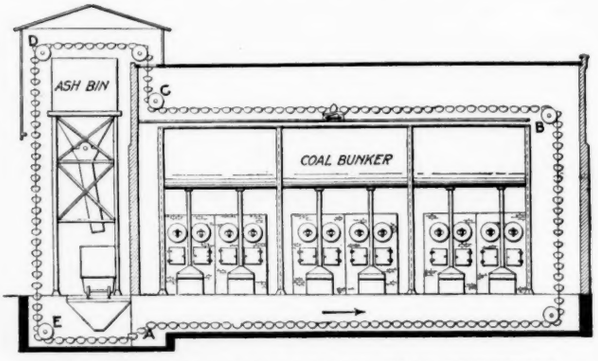
The compressor is lubricated with 2½ pt. per 24 hr., having a variable piston speed of from 120 to 400 ft. per min. All oil is fed through the high-pressure side, there being no lubricator on the low-pressure side. The steam pressure is carried at 130 lb. with about 2 per cent. moisture.

Can any readers of *Power* do better than this?

Birmingham, Ala. EDWARD O. EDNEY.

Correcting Trouble on a Conveyor

Violation of an elementary principle will usually result in considerable trouble, and in a search for the cause of the difficulty the simplest things are often overlooked.



GENERAL LAYOUT OF ASH AND COAL CONVEYOR

In analyzing troubles with plant equipment, it is sometimes wise to forget engineering and apply a little "horse sense."

To illustrate: A bucket conveyor for coal and ashes in a boiler plant of about 3,000 hp. had given trouble from the start, required an excessive amount of power and would handle only a small fraction of its rated capacity. This was at first attributed to the fact that the apparatus was new and had not yet "found" itself, but as time went on, the trouble grew worse. Finally the driving motor burned out, and it was evident that something was radically wrong about the layout.

Many long discussions were held in the New York office at which abstruse theories were advanced. Finally it was decided to send the writer up to the plant as an "expert" to solve the problem—I always did dislike the word "expert."

The action of the conveyor was decidedly weak, and it would hardly run light, refusing completely to convey either coal or ashes. So, casting aside all the complicated blueprints, common sense and a few simple sketches developed the answer in half an hour. The illustration shows the conditions and the run of the conveyor. Coal was delivered in cars, dumped into a hopper under the tracks and fed to the crusher. It then went to the conveyor to be delivered to the overhead bunker. The ashes were dumped on the conveyor at various points, through manholes, for delivery to an overhead bin. There was an offset in the lower horizontal flight of the conveyor at *A*, and on account of building limitations the upper horizontal run was elevated to pass over the top of the ash bin, as indicated. This made matters bad, and the whole run of the conveyor was not conducive to good operation under the best conditions.

The drive was at the point *E*, so that the loaded conveyor was pushed from this point, with the result that the various buckets attempted to climb on the rails and adjacent buckets caused excessive friction or jammed hard enough to stop the conveyor altogether.

The best location for the drive would be at *D*, so that all loaded parts of the conveyor would be pulled, and the second best position would be at *C*, where all except the short vertical run of the conveyor would be pulled. Neither of these locations was practicable, however, on this job, so as a compromise the drive was changed to *B*. In this position most of the loaded runs of the conveyor were pulled by the drive, after which the conveyor operated satisfactorily. That it should be a rule in all such work to pull the loaded runs rather than push them ought to be obvious to anyone, but from lack of proper study of the layout it is not always followed.

Philadelphia, Penn. R. A. LANGWORTHY.

Making a Gland Nut Safe

In the issue of Apr. 4 Mr. Ellison shows a way of making a gland nut safe. The idea of drilling the hole is all right, but it tends to weaken the nut. Also an obstruction in any of the holes might lead to serious accident.

A much simpler way and one that I have always used is as follows: When packing the gland, screw the nut on three or four turns, then with a rule measure the distance from the outer edge of the nut to the cylinder head, and with a scriber mark the distance in numbers on some part of the machine where you can easily see it. Then, any time you wish to slacken the nut, the only thing needed is a rule. By keeping within the distance marked on the machine you are always sure of safety. Numbers or marks are placed on the machine only to avoid forgetting the distances.

Acra, N. Y. W. P. HUMPHREY.

Volatile Matter in Coal

Considerable prominence has been given to a paper on "Selecting a Coal," presented by the station operating committee of the National District Heating Association and accompanied by charts from W. H. Schott, engineer of the Harris Trust Building, Chicago. I cannot agree with the conclusions reached and believe them to be based on a wrong premise.

For example, coal from Streator, La Salle Co., Ill., of 84.9 per cent. total combustible, 48.1 per cent. being fixed carbon and 36.8 per cent. volatile matter, is given credit for an evaporation of slightly over 8 lb. of water per pound of coal, while coal from Cannelton, Ind., 48.3 per cent. fixed carbon and 45.9 per cent. volatile matter, a total of 94.2 per cent. combustible, is given a rating of only 7 lb. of water per pound of coal. That is, with the fixed carbon remaining constant, an increase of 9 per cent. in the volatile matter and with a decrease of 10 per cent. in ash, the coal has lost 12½ per cent. of its heating value.

If this be true, then the purchase of coal on specification, rests on a false basis. The correct way would be to

pay a premium for increased ash and to exact a penalty for volatile matter.

If these charts are true for certain types of furnaces, and they will probably approximate the truth for furnaces designed for anthracite or Eastern coals of low volatile content, would it not be better engineering to redesign the furnace to utilize the heat in the volatile matter than to condemn this on account of shortsightedness?

In Bulletin 29, Illinois Geological Survey, will be found the following: "Volatile matter, fixed carbon and sulphur do not ordinarily enter into consideration in making contracts for the purchase of coal. Pound for pound, volatile matter, as a rule, is likely to have as high or a higher heating value than the fixed carbon. Modern steam-generating appliances should be able to burn one form as readily as the other."

Most of the hydrogen in the coal is in the volatile matter, and when we consider that this has a heat value nearly four times as great as pure carbon, would it not be much better to arrange furnaces to take advantage of this heat than to condemn the coal for carrying it?

Madison, Wis. C. Z. Wise.

Some Rope vs. Belt Figures

Rope drives cost less than belt drives on large units, but first cost should not be the deciding factor.

I have before me an argument favoring rope transmission for a 1,000-hp. drive because the combined cost of rope and pulleys is $900 less than for the belt and pulleys. Allowing both drives a high efficiency—belt 95 per cent., rope 90 per cent. (there is at least 5 per cent. difference)—for the rope drive the brake horsepower of the engine must be 1,000 ÷ 0.90 = 1,110; for the belt drive the brake horsepower must be 1,000 ÷ 0.95 = 1,050, or 60 hp. more would be necessary with the rope drive.

At 1c. per hp.-hr. for 3,000 hr. per yr., the cost would be $30, and 60 hp. would cost 30 × 60 ÷ $1,800 per year; thus at the end of one year the $900 saved in first cost would be doubly lost and each succeeding year $1,800 would be lost.

This of course is nothing new, but is meant to point out that sometimes saving in first cost is not economy.

New York City. S. F. Wilson.

Auto Furnishes Power When Engine Breaks Down

I was interested in the letter in the Apr. 18 issue under the heading, "Auto Furnishes Power When Engine Breaks Down."

While the master mechanic is to be commended for his ingenuity in getting the plant running again, one wonders why a man of his ingenuity had not provided breakdown service of some description, to meet all such emergencies. It seems almost ridiculous to think of a plant requiring only 22½ hp., in which a shutdown of 70 hr. means a loss of $25,000, not having some sort of a duplicate unit or service. An extra boiler and engine, a gasoline or oil engine of the capacity of a Ford automobile engine should not cost very much in comparison with the loss sustained by a single shutdown.

Plant owners sometimes spend freely in equipping other departments in their plants, but when it comes to the motive power, they are satisfied with most any makeshift as long as it will run, going on from year to year, "getting by" with only a slender margin, until the inevitable breakdown comes and ties them up, unless perchance they have an ingenious mechanic—and an automobile.

The power plant is the most vital part of any establishment that has wheels to turn and should be so designed as to be able to meet any emergency, and with a goodly margin to spare. Earl Pagett.

Independence, Kan.

Grease Removal from Boiler Feed Water

According to Kent's Mechanical Engineers' Pocketbook a 1,000-hp. engine should operate properly on less than 8 drops of good lubricating oil per minute, or 480 drops per hour. Assuming the steam consumption at 10 lb. per hp.-hr., 10,000 lb. of water will pass through the engine per hour, will be condensed, and without an oil extractor in the steam line all the oil will be entrained in the water.

One gallon of water weighs 8.33 lb., and there are 31½ gal. in a barrel; 10,000 ÷ 8.33 = 1,200 gal. per hr.; 1,200 ÷ 31½ = 38 bbl. Therefore 38 bbl. of water passes through the engine per hour. Proportioning 480 drops of oil among 38 bbl. of water makes it 12.6 drops per barrel.

It is stated in a recent catalog that a good grease extractor will remove 6 parts in 10,000,000 of the grease contained in boiler-feed water. Therefore only $\frac{6}{10,000,000}$ of 12.6 drops should remain in a barrel, or $\frac{7.56}{1,000,000}$ of a drop, or one drop in 132,200 barrels.

According to these figures it would take 348 days (nearly a year) of 10 hours each for a single drop of oil to get into the boilers, all of which I am inclined to doubt.

New York City. W. F. Schaphorst.

Referring to Mr. Schaphorst's letter, he is correct in doubting that it would take nearly a year for a single drop of oil to get into the boilers, but I think he has either misquoted the statement in the catalog, or the writer of the catalog misused his English and wrote something he did not mean. The statement as given by Mr. Schaphorst is: "A good grease extractor will remove 6 parts in 10,000,000 of the grease contained in the boiler-feed water."

Mr. Schaphorst says that therefore only $\frac{6}{10,000,000}$ of 12.6 drops should remain in a barrel, or one drop in 132,000 bbl. This does not conform to the statement as quoted, which would lead to the conclusion, not that one drop of oil would remain, but that one drop would be removed from 132,000 bbl.

It is probable that the writer of the catalog meant to say that a good grease extractor would remove all the oil from the feed water down to 6 parts of oil in 10,000,000 parts of water. Assume that 480 drops of oil equals 1 cu.in. per hour and 1,200 gal. of water equals 277,200 cu.in. of water per hour. Oil in feed water = $\frac{1}{277,200}$ = 0.0000036. Oil in purified water,

$\frac{6}{10,000,000}$ = 0.0000006, or one-sixth as much, or ⅙ of 12.6, which is 2.1 drops of oil returned to the boiler per hour. Mr. Schaphorst should ask the company that issued the catalog to explain the statement.

Montclair, N. J. WILLIAM KENT.

Reversed Motor Phase

As usually understood, the reversing of one of the phases of a polyphase induction motor refers to the interchanging of two of the stator supply wires in order to reverse the direction of rotation of the rotor. In the present discussion, however, it refers to the actual reversing of one of the complete coils that constitute the internal winding of the stator. The normal connections of the coils of the stator of a three-phase induction motor (delta-connected) are diagrammatically illustrated in Fig. 1, in which the three coils are marked 1, 2 and 3. In Fig. 2 the marking of the coils is the same, but the connection of coil 1 is represented as having been reversed. The effect of reversing one of the coils of the stator is to change the relations of the three magnetic fields due to the three coils so that sets of lines of force that should concur in direction oppose one another, and sets of lines that should oppose concur in direction.

A three-phase induction motor, which was connected to its load through a clutch, was complained of because it would jerk when starting, would emit a peculiar groaning noise and would not attain full rated speed. A maintenance inspector was sent to investigate. The motor was of the slip-ring type; the rotor would come up to about three-fourths speed on the first resistance notch of the controller, but the speed would rapidly decrease when the resistance was cut out by advancing the controller handle.

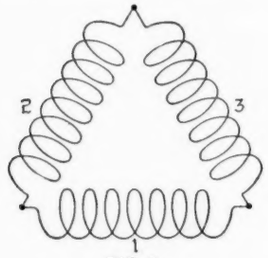


FIG. 1

FIG. 1. REGULAR DELTA CONNECTION

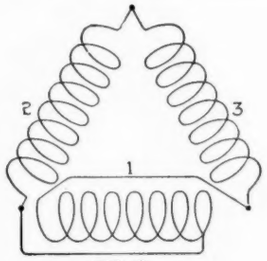


FIG. 2

FIG. 2. ONE COIL OF WINDING REVERSED

Inspection indicated all external connections apparently to be regular, and all circuits rang clear with a magneto. On inquiring as to how long the motor had been irregular in its operation, the attendant said that its performance had been satisfactory up to the time that the stator was repaired. Also he stated that when the motor was reinstalled after its return from the repair shop, it was necessary to reverse two of the line wires in order to get the original direction of rotation of the rotor. Inspection of the end connections then disclosed a reversed internal-coil connection. Had the motor been anywhere near fully loaded, the probabilities are that it would have overheated because of the unbalancing of the phase currents, due to the reversal of the coil. The phase currents were unbalanced as it was, but the connected load was insufficient to overload even the most heavily loaded phase.

Schenectady, N. Y. E. C. PARHAM.

A Cent's Worth of Coal

We have been reading recently about "what a cent's worth of electricity will do" and "what a cent's worth of gas will do," but I have never read "what a cent's worth of coal will do," and so I have done a little figuring with the following surprising results:

Assuming coal to cost $3.50 per ton, a common figure in Eastern power houses, and assuming each pound of coal to contain 12,000 B.t.u., each cent will buy approximately 53,300,000 ft.-lb. I have allowed 2,000 lb. of coal per ton and 778 ft.-lb. per B.t.u. Utilizing 10 per cent. of the coal's energy, we get 5,330,000 ft.-lb. of actual work. This is enough to lift one million pounds through a height of 5⅓ ft. Quite a lift for one cent. Or, to make it "sound bigger," a cent's worth of coal can lift a ton of water against a head of a half-mile, or 2,665 ft., to be more exact. Of course in these computations other costs have not been considered. S. F. WILSON.

New York City.

When Executives Should Keep Silent

Whenever lights go out in a building, factory or town, the first impulse of the executive is to telephone the power station regarding the trouble. In a large factory, for instance, nine-tenths of the foremen will have this impulse, and if the chief engineer had to answer all of these calls, it would delay him 15 to 30 minutes in restoring the power.

If these foremen would only stop to think, they would realize that the chief engineer would be the first to notice that the power had been lost and therefore would attempt to restore it as quickly as possible; consequently all answering of telephone calls would mean simply more delay.

An experience of this sort occurred in eastern Massachusetts when the engineer of a large power plant lost his current. The first thing he did was to take the receiver off his telephone, and immediately thereafter he pulled the switches on his board until current was restored. Then he threw in the switches again, it requiring about 15 minutes to restore power.

Not until then did he hang up the receiver of his telephone, and it immediately began to ring. The first on the line was the president of the corporation, who said: "I have been trying to get you by phone for the last 15 minutes. Where were you? What were you doing?"

The engineer very calmly replied, "I was pulling switches and restoring the current." "Well, why didn't you answer me when I first rang up?" asked the president.

The engineer's answer was: "I took the receiver off of my telephone so I wouldn't be interrupted by a lot of fools. If I had to answer all the telephone calls the current wouldn't be restored for half an hour."

Ever since the president has taken delight in informing visitors to the power plant that his chief engineer is the only one who disobeys him.

The lesson to learn from this is for all engineers who experience similar troubles to make the removal of the receiver of the telephone from its hook their first duty and not to hang it up until power is restored.

Watertown, Mass. WALTER J. BITTERLICH.

Inquiries of General Interest

Advantage of Long Stroke for Ammonia Compressor—What is the advantage of a long stroke over a short stroke for an ammonia compressor? N. A.

For a given piston clearance the clearance volume is a smaller percentage of the piston displacement the longer the stroke of a compressor, hence there is a more complete expulsion of gas from the cylinder for a given piston displacement.

Why Engine Requires More Cylinder Oil—With the same load and steam pressure and same kind of cylinder oil, why should much more cylinder oil be required than formerly to prevent an engine from groaning? G. E. B.

The cause might be a different distribution of cylinder oil and poorer lubrication due to a different quality of steam or method of operating the cylinder lubricator; different condition of the piston-rod packing; cutting or wearing away of the piston rings or bore of the cylinder to material of different texture; or there may have been a change in the alignment of the piston, piston rod, stuffing-box or crosshead, requiring more liberal lubrication of the cylinder.

Formula for Drop of Pressure in Steam Pipe—What is the formula for determining the drop of pressure of steam flowing through pipes of various sizes and lengths? W. G.

The relations of drop in pressure, a given weight of steam flowing in pipes of different diameters and lengths, is given by the formula

$$p = 0.000131 \left\{ 1 + \frac{3.6}{d} \right\} \frac{W^2 L}{D d^5}$$

where

p = The drop in pressure, pounds per square inch;
d = The diameter of pipe in inches;
L = The length of pipe in feet;
W = The weight of steam flowing, in pounds per minute;
D = Mean density or weight per cubic foot of the steam flowing through the pipe.

Advantages of Induced Over Forced Draft—What are the advantages of operation of an induced draft over the use of a forced draft for boiler furnaces? J. D.

In the use of a forced draft requiring a closed ashpit, the blast pressure causes the fire to burn most actively in spots and frequently forces the gases of combustion from joints around the furnace doors in so great a quantity as to affect the efficiency of the boiler and the health of the fireman, besides filling the surrounding atmosphere with fine particles of coal and ashes.

These objections do not occur with the induced-draft system, as the pressure of the air inside the furnace is uniform and less than that of the atmosphere and it is not necessary to shut off the draft when cleaning the fires or ashpit or when firing, and the fire burns more evenly over the entire grate and requires less attention than with forced draft.

Range of Cutoff of Single-Eccentric Corliss Engine—In a single-eccentric Corliss engine, why cannot cutoff take place through a greater range than one-half stroke? W. F.

The eccentric center will be on the line of dead points and the valves will have their greatest displacement when the crank has moved through 90 deg. less the angular advance and before the piston is at half-stroke. Hence, if the detachment gear has not been released by the cam before the valve has received its greatest displacement, the valve will not be disengaged, and in returning over the same portion of the cam, the valve connections will remain under the control of the linkage connecting it to the wristplate. Cutoff will then occur near the end of the stroke and will be determined by the lap and angular advance. Therefore for the ordinary form of the Corliss gear, with a single eccentric, the range of automatic cutoff is from the beginning of the stroke to half-stroke or less.

Increasing Power Developed by Engine—If the power of an engine is to be increased by increasing the speed, raising the steam pressure or enlarging the cylinder, what considerations should be taken into account? J. C.

In any case consideration should be made of the suitability of the foundation, engine bed, bearings and all working parts for the proposed development of power and the changed conditions. If the speed of the engine is to be increased, special attention should be given to the size of steam ports and passages, method of governing, valve gear, sufficiency of piston clearance, lubrication, disturbance of balancing, safety of flywheel and appropriate valve setting. If more power is to be developed by increasing the boiler pressure, the strength of the cylinder, adaptability of valves and valve gear, governing, piston and rod packing, and suitable valves and cylinder lubrication should be provided. If a larger diameter of cylinder is to be provided, a new piston and piston rod and probably new valves will be required, and special attention should be directed to the adaptability of the engine frame and foundation and changes required in the valve gear and crosshead.

Required Diameter of Piston—Neglecting the reduction of piston area due to the piston rod, what diameter and stroke of piston would be required for an engine with a piston speed of 800 ft. and 200 r.p.m. to develop 400 i.hp. with 50 lb. m.e.p.? J. F.

A piston speed of 800 ft. and 200 r.p.m. would require the stroke to be $800 \div (200 \times 2) = 2$ ft.

Substituting in the formula,

$$Hp = \frac{PLAN}{33{,}000}$$

where

P = Mean effective pressure;
L = Length of stroke, in feet;
A = Area of piston in square inches;
N = Number of strokes per minute or r.p.m. × 2;

$$400 = \frac{50 \times 2 \times A \times 200 \times 2}{33{,}000}, \text{ from which } A = 330 \text{ sq.in.}$$

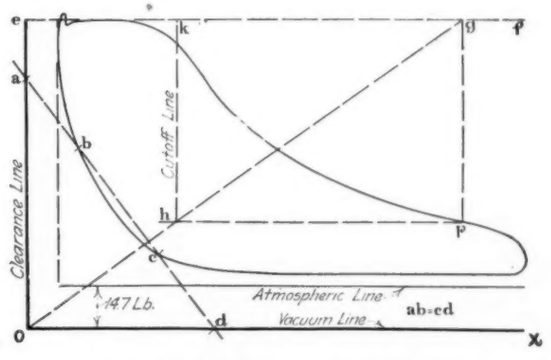
Hence the diameter of the piston should be

$$\sqrt{\frac{330}{0.7854}} = 20.49 \text{ in., or practically } 20\tfrac{1}{2} \text{ in. dia.}$$

Locating Clearance and Cutoff on Indicator Diagram—How are the theoretical clearance and the point of cutoff located on an indicator diagram? J. W. H.

The clearance is preferably located from the compression curve.

First draw the vacuum line OX parallel to the atmospheric line and 14.7 lb. below it, according to the scale of the diagram. Draw a straight line abcd across the compression curve cutting OX at d and lay off ab = cd. Through a erect the perpendicular aO and this will be the clearance line.



LOCATING CLEARANCE AND CUTOFF

To determine the theoretical point of cutoff, first draw ef parallel to the atmospheric line to represent the initial pressure line and, selecting any point p in the expansion curve near the point of release, erect the perpendicular pg. Draw a diagonal from g to O. From p draw ph parallel to the atmospheric line, and from the point of intersection of ph and gO draw the vertical line hk. This will be the cutoff line, and the theoretical point of cutoff for the assumed initial pressure will be at k.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Experiments on Water Flow Through Pipe Orifices*

By Horace Judd†

SYNOPSIS—When a fluid flows through a constricted orifice in a pipe, its pressure falls with the increase of velocity. The greatest velocity and hence the greatest fall of pressure is not at the orifice itself, but about one-half the pipe diameter from the diaphragm. Coefficients for thin orifices of various types and for cap orifices are given.

The chief objections to the pipe orifice have seemed to be that a special form of orifice flange was needed and that considerable uncertainty prevailed concerning the pressure conditions adjacent to the orifice, so that the working coefficients for an orifice in a pipe were not so reliable as those of the venturi meter or the pitot tube.

About two years ago, while employing the Bailey meter[1] to measure the steam used by an engine, the writer became interested in the orifice as a pipe-flow measuring device. It was important to know at what point near the orifice the attachment should be made in order to measure correctly the pressure drop of the steam flowing through the orifice. It was thought at the time, both by Mr. Bailey and the writer, that an investigation would reveal many valuable points concerning the flow conditions through the orifice in a pipe. The present line of work is the final outcome of this thought and has been carried on in connection with water flow, since water could be more easily handled than steam, the intention being to continue later with a study of the flow conditions in a steam line.

The paper is really a record of progress, for only a few points have been touched upon, such as the pressure changes in the vicinity of the diaphragm, or orifice; the probable location of the least section, or zone of greatest velocity of the water jet; and the working coefficients of the diaphragms; leaving many other points of equal interest and importance to be studied later. The experiments were confined to one size of water pipe (5-in.) and the pressure drop through the diaphragm did not run much in excess of 6 ft. of water, which was considered to be the probable maximum drop desirable to use in connection with any automatic registering device. For the largest diaphragm this range of pressure drop gave a maximum velocity of 17.5 ft. per sec.

In general, the purposes of the tests were: (a) To discover the pressure relations existing immediately above and below an orifice diaphragm in a pipe in order to determine the most suitable points for making the pressure connections (for the manometer); (b) to note the position of greatest pressure drop due to flow through the orifice, or the probable point of greatest velocity, corresponding to the point of least section of a jet of water flowing freely into the air; (c) to obtain reliable coefficients of discharge for orifice diaphragms of different diameters.

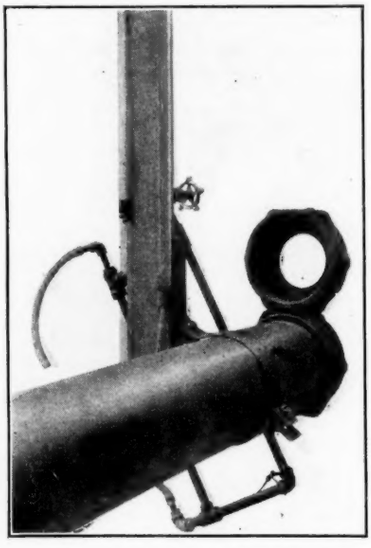


FIG. 3. ORIFICE AT END OF PIPE WITH MANOMETER CONNECTION

For these experiments a horizontal line of 5-in. standard pipe was used, approximately 42 ft. long, in which was located an extra-heavy flanged coupling for holding the orifice diaphragms. In Fig. 1 is a view of the pipe, flanges and manometer connections, and from the diagram in Fig. 5 it will be seen that the location of the diaphragm is 21 ft. 11 in. elbow an ell and 20 ft. 2 in. from the discharge end of the pipe, on which is screwed a cap having a discharge orifice, Fig. 3. These orifices furnished a means for regulating the water contents of the pipe below the diaphragm and so to control more easily the pressure drop through the orifice. Their use also gave an opportunity to secure data for computing the coefficients of discharge for this form of orifice. Water was supplied to the pipe line by a 6-in. centrifugal pump directly connected to a steam turbine. The water was measured by several large measuring bays.

The diaphragms, Fig. 2, were formed from plates of monel metal $\frac{1}{32}$ in. thick, with the outer rings of their surfaces, above 5.1 in. diameter, corrugated to form a tight joint between the flanges, without the use of gaskets. The orifices were bored out accurately to size and were of three types: (1) Concentric

*Abstract of a paper presented at the spring meeting, New Orleans, La., April, 1916, of the American Society of Mechanical Engineers.

†Professor of experimental engineering at the Ohio State University.

[1]See "Power," Apr. 18, p. 534.

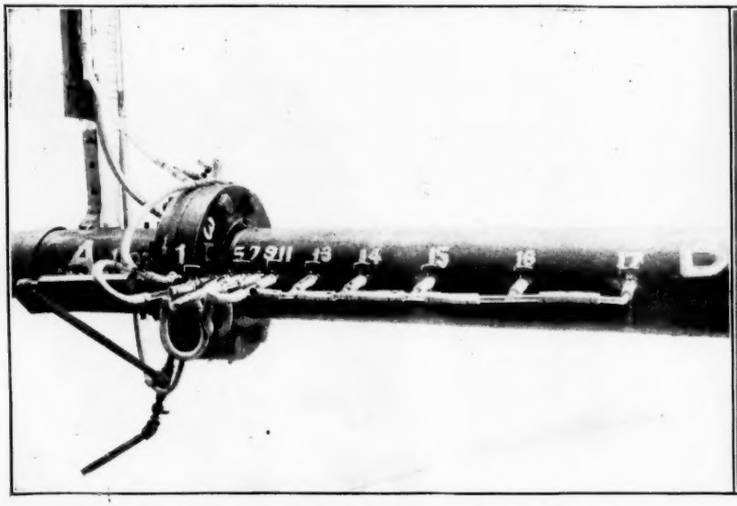


FIG. 1. MANIFOLD AND MANOMETER CONNECTIONS AT THE DIAPHRAGM FLANGE

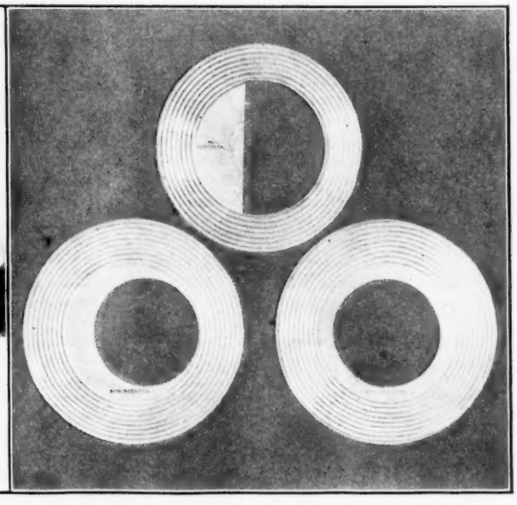


FIG. 2. MONEL METAL DIAPHRAGM; 80 PER CENT. SIZES USED

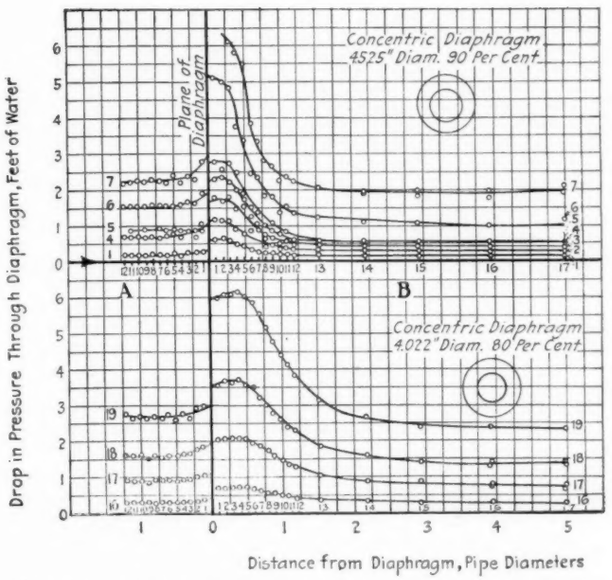


FIG. 4. 80 AND 90 PER CENT. CONCENTRIC DIAPHRAGM

with the rim of the diaphragm; (2) eccentric with the rim; and (3) segmental. Eight concentric and two each of the special forms were tested. They were furnished by E. G. Bailey and are of the standard form used in the Bailey meter. Fig. 4 shows the locations of the pressure connections for the manometer, which are spaced along lines on diametrically opposite sides of the pipe in a horizontal plane with its axis. Above the diaphragm, on the upstream side, there are 6 connections on each side of the pipe, and below the diaphragm there are 11 connections. It will be seen that on the right side of the pipe, looking downstream, the pressure connections begin at a point ½ in. from the plane of the diaphragm and that the first six connections are spaced 1 in. apart; while the remaining five points on the downstream side are spaced respectively 2½, 3, 4, 5 and 5⅛ in. apart, making the last one, No. 17, five pipe diameters from the diaphragm plane.

The connections on the left side are similarly placed, except that those nearest the diaphragm are 1 in. from it, instead of ½ in., and that the five connections farthest away from the diaphragm are opposite those on the right side. A second water-gage glass (shown in Fig. 1 with a rubber tubing leading to a connection at the bottom side of the pipe) was used to indicate the head on the diaphragm and aid maintaining constant water head.

The complete manifold arrangement (see Fig. 5) made it possible to maintain a pressure difference, or drop, between any point of connection above and any point below the diaphragm without disturbing the gage-glass which indicated the head on the upstream side of the pipe. The static head at the cap orifice was read at a point 7.5 in. from the plane of the orifice on a water column whose zero scale reading was on a level with the center of the pipe.

The pressure differences as measured between two points above and below the nozzles—that is, upstream and downstream—are given in the paper in tabular form and in diagrams of which Figs. 4 and 6 are typical examples. In curve 18 in the lower half of Fig. 5, for example, the upstream connection was at A5, one-half the pipe diameter from the diaphragm. At B1 the pressure drop was equivalent to 3.55 ft. of water and is laid off vertically from the base line. For B3 and B5 the pressure drops are 3.63 and 3.55 respectively, and so on. The pressure drops on the upstream side are measured from B14 as a fixed point. For the concentric orifice, Fig. 5, the pressure drops for the opposite sides of the pipe form a single curve and are plotted together. For the eccentric and segmental orifices the flow is quite different on opposite sides of the pipe and a separate curve is given for each side, as in Fig. 6.

The restoration of pressure varies from 77 per cent. restored by a concentric nozzle of 90 per cent. of the pipe diameter to only 4 per cent. of the initial pressure restored with a concentric orifice the diameter of which is only one-fifth that of the pipe. For the eccentric and segmental orifices the restored pressure falls from 65 per cent. of the initial

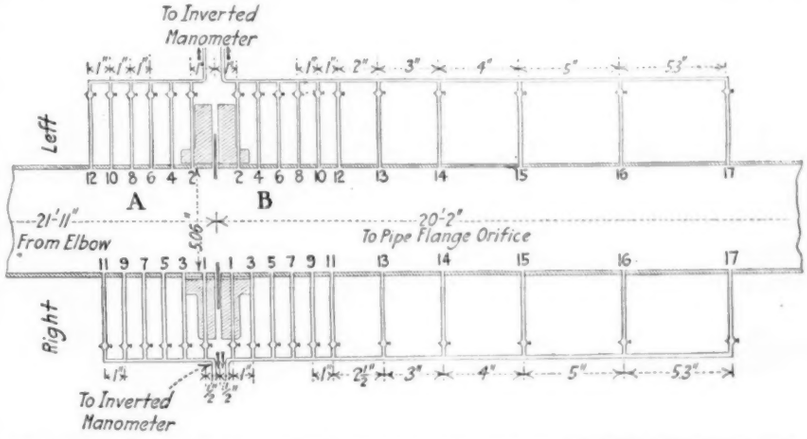


FIG. 5. POSITION OF DIAPHRAGM FLANGE AND PRESSURE CONNECTIONS

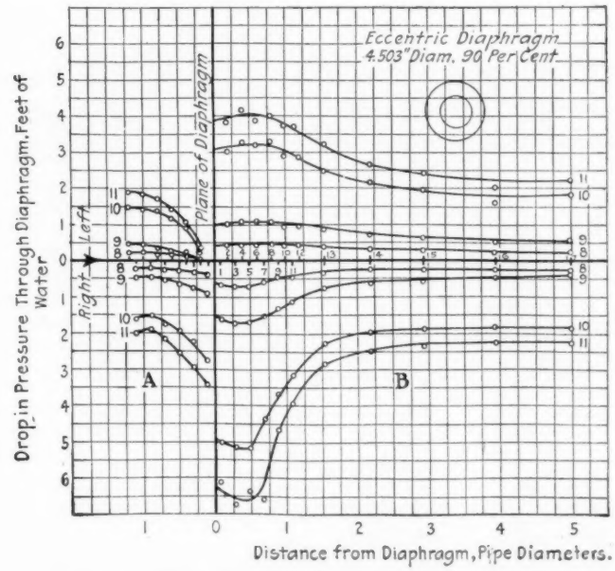


FIG. 6. 90 PER CENT. ECCENTRIC DIAPHRAGM

with orifices having a diameter 90 per cent. of that of the pipe (or equivalent areas) to 54 per cent. for the segmental and 57 per cent. for the eccentric of 80 per cent.

The conclusions arrived at are as follows:

1. A thin plate orifice inserted in a pipe is as reliable for flow measurement as the thin plate, or frictionless orifice.

2. The shape of the pressure-drop curves indicates a maximum point at about one-half pipe diameter from the diaphragm, indicating a zone of maximum velocity of flow.

3. The eccentric and segmental diaphragms are advantageous in that they increase the drop reading, but more care is necessary in making the pressure connections.

4. The best point for the pressure connection is not less than one-half pipe diameter from the diaphragm on the downstream side, and not less than one pipe diameter from the diaphragm on the upstream side of the pipe.

5. The 80 per cent. diameter size of diaphragm should not be exceeded to secure uniform flow conditions and to insure steady pressure-drop readings.

6. The average coefficient of discharge for a 5-in. pipe diaphragm agrees very closely with the average coefficient of discharge for the 5-in. pipe-cap orifice.

7. The coefficients of the pipe diaphragms vary more nearly in accord with the variation in size of diaphragm orifice than those for the pipe-cap orifices.

8. The agreement is closer for the coefficients for all the pipe orifices at about 80 per cent. diameter ratio.

9. The point of maximum velocity of flow is apparently a function of the pipe diameter; not of the diaphragm orifice.

10. The restoration of pressure in the downstream side is apparently a function of the area of the diaphragm.

On the Transmission of Heat in Boilers*

By E. R. Hedrick† and E. A. Fessenden‡

The authors have found difficulty in checking the results of experiments quoted in the literature with the theories commonly proposed for the transmission of heat from the hot gases to the water in the boiler. In particular the formulas given by Sir John Perry and others appear not to check with the data given by various writers.

In working over this matter, the authors have been led to an assumption which seems particularly reasonable in view of the fact that the resistance to heat transfer changes almost certainly with the temperature on account of the dependence of the resistance on the behavior of the film of gas next to the pipe and of the film of water next to the pipe, rather than on the material of the pipe itself. The authors were led to make the assumption that the quantity of heat lost by a given small weight of gas falls off as the gas passes down the pipe in accordance with the ordinary damping law usual in physical phenomena. After working with this hypothesis for some time and finding that it agreed with the data better than the formulas usually given, the authors have found that an equivalent assumption of simple character can be stated in terms of the difference in entropy of the gas at the temperature of the gas and of the gas at the temperature of the water. The assumption is that the rate of change of this difference is proportional to this difference, where the rate is taken with respect to the actual distance down the tube.

The theoretical consequences of such an assumption are worked out in some detail, and they are brought to the point where graphical check with numerical data is easily possible. The actual comparisons with the theory of Sir John Perry and with that of this paper are shown by a number of graphical figures so arranged that the points should lie on straight lines in each case if the corresponding theory is correct. It is found that the agreement is quite a little better with the theory of this paper than with that of Perry. The data used are the old French experiments, a set of experiments furnished by Prof. William Kent, several sets of experiments conducted by the Pennsylvania R.R. and a large series of tests conducted at the University of Missouri by Prof. E. A. Fessenden. Data furnished the authors by the Babcock & Wilcox Co. after the paper was written are discussed in the addendum.

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Proposal to Build Government Nitrate Plant

If the House of Representatives concurs in what is known as the Smith amendment to the Chamberlain army reorganization bill, the United States Government will build and operate one or more water-power plants for the manufacture of atmospheric nitrogen. This product, in turn, will be utilized by the Government primarily in the manufacture of explosives for the army and the navy, and any surplus not required for this purpose may be disposed of as the Secretary of War may direct.

The Smith amendment first made its appearance in Congress as a bill designed to build and equip a Government plant for the manufacture of nitrogen fertilizer, any surplus product to be used for the production of explosives for the army and navy. As a fertilizer bill, it was referred to and reported by the Committee on Agriculture, but as it emerged from that committee, it provided primarily for the manufacture of atmospheric nitrogen for war and navy uses, the fertilizer product being incidental.

Senator Smith then offered his bill, as reported, as an amendment to the army reorganization bill; it was referred to the Military Committee and by that committee referred back to the Senate without recommendation. After days of discussion the amendment was further altered, and was finally adopted by a vote of 43 to 22.

As adopted, the Smith amendment authorizes the President to set aside for the exclusive use of the United States Government not to exceed five water-power sites upon navigable streams, the selection to be made by the Secretary of War.

Plants at a cost of $15,000,000 are to be constructed and operated solely by the Government and not in conjunction with any other industry or enterprise carried on by private capital. To finance the project, the Secretary of the Treasury is authorized to sell Panama Canal bonds to the amount of $15,000,000.

While the amendment, on its face, leaves the selection of a site or sites to the Secretary of War, it was repeatedly explained during the Senate debate that the Government power plant and nitrate factory will be established at Mussel Shoals, on the Tennessee River, in northern Alabama, that site having been examined and reported upon favorably by the army engineers. It further was disclosed in the debates that the engineers' estimates on the Mussel Shoals project fix the cost of that project, complete, at $18,500,000. So it is generally accepted that the Smith amendment means the establishment of a government factory on the site named.

Although the Smith amendment would provide for only one nitrate plant, it is said that there are half a dozen or more water powers in the United States where power can be developed in units sufficiently large and at prices sufficiently low for use by atmospheric nitrogen industries. It has also been pointed out that while a single large plant might be enough to guarantee a Government supply of nitric acid for the manufacture of military and naval explosives, its effect upon fertilizer production would be only a drop in the bucket as compared with the country's agricultural needs.

Congress has been told that private enterprise is ready to invest $100,000,000 or more in water-power development and atmospheric nitrogen plants if Congress will pass general laws permitting the use of water powers and sites on navigable streams and in the public domain, on terms that will justify the investment.

While the Smith amendment was under consideration in the Senate, the Du Pont Powder Co. proposed to the Secretary of War to build a nitric-acid plant to cost $20,000,000, if allowed the use of a power site, and to furnish the United States with nitric acid at a price to be fixed by the Government.

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National Electric Light Convention

The thirty-ninth convention of the National Electric Light Association will be held in Chicago, May 22-26, at the Congress and Auditorium Hotels; the exhibits of the electrical manufacturing industries will be shown in the Auditorium Theater. This year the Electrical Vehicle Association of America has accepted the invitation of the Electric Light Association to affiliate and will become a part of it as a new section.

Special trains will be run to the convention, leaving New York on Sunday, May 21, at 11:06 a.m. over the Pennsylvania and at 12:05 p.m. over the New York Central, and from St. Louis at 9 a.m., Monday, the 22nd. Special round-trip rates have been secured.

An elaborate program of papers has been prepared, covering the general and executive, technical and hydro-electric, commercial, accounting and electric-vehicle sections; simultaneous sessions being necessary as usual. That part of the program of particular interest to "Power" readers is as follows:

Tuesday, May 23, 10 a.m., General and Executive Session—Welcome to the city, Mayor Thompson; address of President Lloyd; announcements; report of committee on organization of the industry (membership), George Williams; report of the secretary, T. C. Martin; report of insurance expert, W. H. Blood, Jr.; report of committee on progress, T. C. Martin; report on Question Box, S. A. Sewall; report of committee on relations with educational institutions, J. F. Gilchrist; report of committee on company sections, F. J. Arnold.

Tuesday, May 23, 12:30 p.m., Technical and Hydro-Electric Session—Chairman's address, Holton H. Scott; report of committee on meters, C. G. Durfee; report of committee on electrical measurements, values and terminology, A. E. Kennelly; paper, "Lightning Protection for Transformers," D. W. Roper.

Tuesday, May 23, 8:30 p.m., General and Executive Session—Report of committee on public policy, W. W. Freeman; report of committee on taxation of public utilities, John A. Britton.

Wednesday, May 24, 10 a.m., Commercial Session—Report of committee on wiring, R. S. Hale; report of committee on lamps, Frank W. Smith; report of committee on electric ranges, W. R. Putnam; election of committee on nominations.

Wednesday, May 24, 2:30 p.m., Technical and Hydro-Electric Session—Report of committee on underground con-

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*Abstract of paper presented at the spring meeting of the A. S. M. E., New Orleans, Apr. 11-15.

†Department of Mathematics, University of Missouri.

‡Associate professor Mechanical Engineering, University of Missouri.

struction, E. B. Meyer; report of committee on overhead line construction and inductive interference, R. J. McClelland; report of committee on hydro-electric and transmission progress, T. C. Martin. Commercial Session—report of power sales bureau, C. J. Russell; paper, "Central Station Service in the Manufacture of Artificial Ice," C. J. Carlson; report of committee on new industrial applications of electricity, P. Torchio; report of industrial electric heating bureau, C. F. Hirshfeld.

Thursday, May 25, 10 a.m., Technical and Hydro-Electric Session—Report of committee on accident prevention, Martin J. Insull; report of committee on prime movers, I. E. Moultrop; report of committee on electrical apparatus, L. L. Elden.

Thursday, May 25, 2:30 p.m., Technical and Hydro-Electric Session—Report of committee on street lighting, S. B. Way; report of committee on power supply for the electrification of steam railroads, Peter Junkersfeld; paper, "Central Station Electric Systems and Railroad Power," J. Darlington. Commercial Session—Paper, "Temporary Service for Municipal Sub-Service and Other Construction," C. K. Nichols; paper, "The Resistance Heater as a Load Builder," E. F. Collins; paper, "Electric Furnaces," R. H. Tillman; paper, "Electric Welding," S. R. Dresser; report of committee on competitive power sources, E. F. Tweedy.

Friday, May 26, 10 a.m.—Awarding Doherty, Williams and Frasse prizes; report of nominating committee; report of committee on president's address; report of committee on memorials; report of committee on resolutions; election and installation of officers for the coming year; adjournment of the convention.

Water-Power Conference at Washington

"The Development of Water Powers" formed the topic for discussion at the conference of the American Institute of Electrical Engineers and the American Electrochemical Society at Washington, D. C., on Apr. 26 to 29. The first day was devoted to the Institue meeting under the auspices of the Committee on Water Power and the local section, and part of the second day to water-power subjects as part of the program of the general meeting of the Electrochemical Society. The remaining two days of the meeting were devoted to purely electrochemical subjects. Headquarters were at the New Willard Hotel.

President Carty opened the Institute meeting by referring to the growing influence of the great engineering societies in national affairs, as exemplified by the request of President Wilson for their coöperation in the industrial-preparedness campaign and the naval advisory board. He believed the Institute could accomplish further service to the nation by acting in an impartial and advisory capacity relative to such questions as water-power development.

The first paper of the session was by Lawrence Addicks and dealt with "Electrochemical Industries and Their Interest in the Development of Water Powers." The speaker laid stress upon the necessity for cheap power if electrochemical industries are to be further developed in this country. The amount of power used per ton of output is enormous in many of these processes, and its cost forms a large proportion of the cost of the product. With aluminum, for instance, it is as high as 25,000 kw.-hr. per ton. Niagara power at $20 per horsepower-year, he regarded as too expensive for such work; in fact the modern steam plant, located near the coal fields, could easily compete at this figure. Niagara Falls has become the center of many industries not solely because of its power facilities, but also because of the proximity of many of the raw materials such as carbon, salt and silica, and its favorable location as regards transportation. As the electrochemical industries had been hardly strong enough to develop large powers themselves, Mr. Addicks believed a liberal water-power policy on the part of the Government would be a step in the right direction.

In discussing Mr. Addicks paper, H. G. Stott said that while there has been a relatively small increase in the operating efficiency of the hydro-electric plant in the past 10 or 15 yr., the steam plant has cut the costs about one-half during this period. Also he considered that below about 60-per cent. load factor, the steam plant, where coal is reasonable, can beat any hydro-electric plant. The real solution to the problem, as he viewed it, is a combination of hydro-electric and steam plants.

Dr. A. S. Cushman followed with a paper on "Water-Power Development and the Food Problem," in which he showed that the increase in population of the United States has been chiefly in urban districts rather than the rural sections. This has resulted in a continuously growing demand for food with a relatively small proportion of our population as food producers. The solution, therefore, must lie in more intensive farming, which in turn requires large quantities of fertilizer. This offers a large market for the production of nitrogen, which is one of the principal fertilizer ingredients. The nitrogen can best be produced from the atmosphere, but this requires cheap power in large quantities.

"The Relation of Water Power to Increased Transportation" was discussed by L. B. Stillwell, who stated the total expenditure for fuel for locomotives by all the railroads in the United States for the year ended June 30, 1914, to be $243,000,000, or 11.05 per cent. of the total operating expenses. A large reduction could be effected by electrification if water power were available at low rates. As an illustration he quoted the electrification of the Chicago, Milwaukee & St. Paul R.R.

Two papers were presented at the evening session—one on the "Relation of Water Power to the National Defense," by W. R. Whitney, and the other on "The Water-Power Situation, Including Its Financial Aspect." The former, which in the absence of the author was read by Mr. Finney, pointed out that the United States has no adequate domestic source of fixed nitrogen and is dependent upon imports of nitrates from Chile. In case of war this supply might be cut off. Therefore it is essential that we develop industries for the production of nitrogen from the atmosphere. The product would also supply a growing need for fertilizers and dyestuffs ingredients in times of peace. The two principal processes are the "arc" and the "cyanamid," the former being the more direct method, but requiring about four times the electrical energy per ton of nitric acid. There are several large installations in Norway employing the arc process, but as the author pointed out, Norway's water powers differ essentially from our own. Nowhere in the United States, not even at Niagara, are there existing grouped conditions such as could compete successfully in cost of power with Norway. There they have a fortunate combination of exceedingly elevated water level of dependable and high rate of uninterrupted flow, with immediate ocean-shipping facilities and well-established markets close at hand.

Mr. Dunn's paper was an attempt to present from the viewpoint of the engineer certain aspects of the attitude of capital toward water powers. Actual and threatened laws, popular prejudices and some cases of unprofitable developments in the past have retarded the development of water powers, but there are also physical and natural difficulties which handicap hydro-electric as compared with steam-electric plants, and make it essential that a reasonable profit in promotion be offered, in order to induce investment.

The cost of water power is rising, on account of the increasing cost of labor and materials and increasing taxation, and the efficiency of the utilization of water power has practically reached its maximum. On the other hand, the cost of steam-electric power is falling, in spite of a steady rise in the cost of coal, because continual improvements are being made in the efficiency of conversion of heat energy into mechanical power, and still further progress is to be looked for. To offset this disadvantage the author is of the opinion that large amounts of secondary power from hydro-electric plants may be used for industries and processes that do not necessarily require continuous power.

The hydro-electric plant usually requires about three times the capital investment needed for a steam-electric plant of equal capacity, and the activity of capital in a hydro-electric plant is very low—much lower than in a steam station and in almost all other branches of industry.

"State regulatory bodies," said Mr. Dunn, "have hampered water powers by not recognizing the distinction between bond interest as a compulsory expense paid as the rent for money loaned, and dividends as an earned reward for the risk of the business and skill in management. Another factor that must be more clearly determined in order that the hampering effect of uncertainty may be removed, is the length of time a permit or franchise may run before recapture clauses can take effect, and the question whether these provisions should not cover the power development in its entirety."

Doctor Baekeland, in discussing the paper, said that wasteful methods of financing were responsible for the imposition of unreasonably high fixed charges which in turn mitigated against cheap power.

AMERICAN ELECTROCHEMICAL SOCIETY

A symposium on Niagara Falls Power and American Industries was presented in four parts: I. "The Power Development," by I. R. Edmands. II. "Electric Furnace Products," by F. J. Tone. III. "The Chemical Industries," by A. H. Hooker. IV. "The Nitrogen Question," by W. S. Landis.

Mr. Edmands' paper stated that although the treaty of 1910 between the United States and Great Britain fixed the maximum diversion of water at Niagara as 36,000 cu.ft. per sec. on the Canadian side and 20,000 cu.ft. per sec. on the American side, the War Department has so far withheld permission to use over 15,600 cu.ft. as had previously been allowed by the Burton Act. At present there is developed 215,000 hp. on the American side and 360,000 hp. on the Canadian side. About 175,000 hp. of the latter is transmitted to the United States. The treaty stipulates, however, that not over one-half the power developed on the Canadian side shall be sold in the United States, and this limit has now been practically reached. There still remains unused, but permitted by the treaty, about 7,000 cu.ft. per sec. on the Canadian side and 4,400 cu.ft. on the American side, the latter equivalent to about 80,000 hp. Whether half the power from the former would be available on the American side is questionable, as the Canadian government is adopting a policy of limiting exportation of power, with a view to bringing industries to that side of the border.

It appears that there is going on an impairment of the Horseshoe Falls due to a recession of the rock at the apex, which diverts the water from the sides. Mr. Edmands suggested that this might be arrested by placing a submerged dam immediately above the falls. This, he believed, would render available an additional 25 per cent. of the average flow, equivalent to 1,000,000 hp., without destroying in any way the scenic beauty of the falls.

In discussing this paper Mr. Addicks offered the suggestion that an arrangement might be made whereby all the water from Niagara might be utilized for power purposes six days in the week, the plant then being shut down and the water turned over the falls on Sundays. This, he argued, would meet the contentions of those who wished the falls preserved for their scenic effect, would satisfy the hotel keepers at Niagara Falls and be fair to the industrial interests.

Two illustrated lectures, one on "Reclamation Service Water Power," by A. P. Davis, chief of the Reclamation Service, and the other on "Water-Power Development for Electrochemical Purposes," by J. H. Pierce, concluded the water-power program.

CO_2 Recording Instruments

Instruments for recording carbon dioxide in flue gases are described in Bulletin 91 of the Bureau of Mines, Department of the Interior. J. F. Barkley and S. B. Flagg, authors, in explaining why the bureau has issued a report, state:

In the past few years an awakened activity in power-plant economies has resulted in a marked improvement in the equipment for generating and utilitizing steam. Although the improvement in design and construction of steam-driven prime movers has been greater than that of the steam-generating equipment, the economies obtained with the more efficient engines and turbines have stimulated interest and activity in eliminating unnecessary boiler and furnace losses.

Much attention has been given to the boiler room in efforts to obtain proper combustion of the coal, because of the importance of the coal item in costs of power production. As evidence of this increasing interest may be cited the record of the development within the past few years of new apparatus for the analysis of flue gases. Many new forms of apparatus have appeared, including those for the determination of carbon dioxide, oxygen and carbon monoxide, and others for indicating and for recording the content of carbon dioxide only, as carbon-dioxide content is usually a good indicator for the control of furnace operation.

Because of the large number of steam-power plants operated by the Federal Government and the number of carbon-dioxide recorders used therein, the Bureau of Mines undertook to collect information regarding the practical application of such recorders. Articles published from time to time concerning carbon-dioxide recorders have been mostly descriptive, giving little reliable information as to the results that could be expected from the various types of instruments in ordinary practice, the most of the tests made have been of a laboratory nature.

Tests of several different types of recorders were made under service and laboratory conditions in order to obtain needed information. The purpose of the Bureau of Mines in publishing the results is to show the factors which may affect the accuracy of a carbon-dioxide recorder and the manner in which a recorder should be tested.

Copies of this bulletin may be obtained free of charge by addressing the Director, Bureau of Mines, Washington, D. C.

Wind Wrecks Kansas Plant

The Coffeyville, Kan., power plant shown herewith was badly damaged Friday, Mar 24, by a wind storm of cyclonic velocity. The five smoke-stacks were blown down, and part of the building was demolished. Services was cut off for five days. The cooling tower for the ice plant also was blown down.

WIND-WRECKED LIGHTING AND ICE PLANT, COFFEYVILLE, KAN.

ENGINEERING AFFAIRS

The Ohio Society of Mechanical, Electrical and Steam Engineers will hold its next meeting at Cleveland on June 15 and 16. Details of the program will be furnished in a later issue.

Yonkers Association No. 28, N. A. S. E., of New York, held its second annual entertainment and reception on Apr. 28 at Hollywood Inn. The program consisted of musical and literary numbers, followed by dancing. Lewis Bernard, Joseph Ryan, Arthur Chambers, Charles Wittemore and William Roberts were the arrangement committee.

The New York Section, A. S. M. E.—The final meeting of the 1915-16 season of the New York Section of the American Society of Mechanical Engineers will be held Tuesday evening, May 9, in the Engineering Societies' Building, 29 West 39th St. The paper of the evening will be a "Report upon Efficiency Tests of a 30,000-Kw. Cross-Compound Steam Turbine," by Henry G. Stott and W. S. Finley, Jr., both of the Interborough Rapid Transit Co.

The National District Heating Association will hold its eighth annual convention in New York City, May 16-19, with headquarters at the Hotel Martinique. Papers of interest will be presented at all of the sessions with the exception of the opening one on Tuesday and that devoted to the election of officers Wednesday afternoon. A banquet will be held Friday evening. All who are interested in district heating are invited to be present at all sessions.

The Combined Associations of the N. A. S. E. of Manhattan and the Bronx held their annual banquet at the Walton Hotel, 70th St. and Columbus Ave., New York, on Apr. 29. James D. Taylor, of No. 44, was given an engrossed set of resolutions, in appreciation of his many years of active service; Fred Felderman made the presentation speech. J. H. Coons was chairman of the banquet committee. There was entertainment between the courses of the dinner and dancing concluded the evening.

Engineers and Architects Club of Louisville—The principles of gyroscopic action were explained by Dr. C. L. Mees, president of Rose Polytechnic Institute, Terre Haute, Ind., in an address before a recent meeting of the Engineers & Architects' Club, of Louisville. Dr. Mees made clear in non-technical language the natural laws governing the action of gyroscopes, and illustrated his lecture with the aid of toy tops and other apparatus. In this connection Dr. Mees discussed the uses to which the gyroscope is put and described some of the dangers resulting from its use.

NEW PUBLICATIONS

OXYACETYLENE WELDING AND CUTTING: ELECTRIC, FORGE AND THERMIT WELDING. By Harold P. Manly. Published by Frederick J. Drake & Co., Chicago, 1916. Size, 4¼x6½ in.; 215 pages; 56 illustrations. Price, leather, $1.50; cloth, $1.

That the workman may understand the principles and the materials employed in this work, much information is given on the uses and characteristics of various metals, on the production, handling and use of the gases and other materials that are a part of the equipment, and on the tools and accessories for the production and handling of these materials. The work includes the application of the rules of the insurance underwriters which govern this work, as well as the instructions for the care and handling of the generators, torches and materials. Special attention has been given to definite directions for handling the different metals and alloys that must be used. The instructions have been arranged in the form of rules placed in the order of their use during the work described.

COAL AND COKE. By Frederick H. Wagner. Published by the McGraw-Hill Book Co., Inc., 239 West Thirty-ninth St., New York, N. Y. Pages, 431; 6x9 in.; figures, 137. Price, $4.

The liberal supply of natural gas in many of the early steel-work districts and the development of the water-gas generator for illuminating gas retarded the development of coal-gas plants in America. Later came a period of low-priced fuel oil, and its advantages in the way of cheap installation and easy control caused its wide adoption in metallurgical work. When the price of fuel oil began to increase, coal gas found a new rival in powdered coal. On the other hand, England has been steadily developing coal-gas plants and makes a much wider use of their product than we do in America. However, the United States Bureau of Mines has published some valuable bulletins on this subject, and good work has been done by the University of Illinois, but undoubtedly the future will show considerable advance.

The book starts with a classification of coal showing the graduation in its formation. Thus starting with wood fiber, next comes peat, then lignite, earthy brown coal, bituminous coal, semibituminous coal, semianthracite and anthracite. The various graduations show less and less oxygen and more and more carbon. In addition to their chemical analysis, the selection of coking and gas coals requires a knowledge of the resultant distillations and the different volatile products that result when the time and temperature conditions are taken into account. The selection of coal samples for analysis requires the utmost care, and the chapter on analysis includes the preparation of samples and the common forms of analysis and calorimeter calculations. The preparation and storage of coal is outlined, with illustrations of mixers, conveyors and storage plants.

The second and larger part of the book covers coke, both the beehive or byproduct oven coke and gas coke with the carbonization in retort benches, and illustrations of the different types of benches and cross-section drawings of retort houses. It goes well into combustion, flue-gas analysis and the power produced with the waste heat, ending with illustrations and discussion on coke-handling machinery and coke plants.

As mentioned, the larger part of the book is on coke manufacture and covers this subject quite fully. Besides being of interest to those engaged in this line, the volume will be useful in placing before the student data and information in concise form covering the various systems of coal carbonization.

BUSINESS ITEMS

Link-Belt Co., Chicago, Ill. Booklet No. 238. Grab buckets. Illustrated, 12 pp., 3½x6½ in.

Girtanner-Daviess Engineering & Contracting Co., Chemical Building, St. Louis, Mo. Catalog. Vacuum ash removal system. Illustrated, 12 pp., 4x8 in.

Washburn and Granger, 50 Church Street, New York, have issued a new grate bar catalog known as catalog No. 7 describing and illustrating the Dean Shaking Grates for soft coal and Dean Dumping Grates for small anthracite. They will be glad to send copies to anyone interested.

The Canton (Ohio) Electric Co. has been authorized by its stockholders to increase its capital stock from $2,500,000 to $12,500,000. The name of the company will be changed to the Central Power Co. The company will take over now the Ohio Light and Power Co., operating in central and northwestern Ohio, and plans for acquiring other large public-service corporations operating in the state will be carried out. It proposes to erect a large power plant on the Ohio River, near Wheeling, from which power may be transmitted to Canton and other cities.

Classified Ads

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